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CHILD DEVELOPMENT

In this number there are reports on the influence of Nursery School and size of Kindergarten group upon school adjustments, of language and motor development, and of physical resemblance in siblings.

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CHILD DEVELOPMENT

Contents for December

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The Influence of Size of Kindergarten Group upon Performance[1]

Helen C. Dawe

THE relative merit of large and small classes and of the various seating positions within the group has been of considerable interest to teachers and workers in the field of education and psychology, but investigations of the problem have been confined to the elementary grades and to classes at high school and college level. The present study aims to determine the effect, at kindergarten level, of the size of the group and of the child's position in that group upon the amount learned and upon the contributions made to group discussion.

The earlier studies (as summarized by Hudelson (4)) are not, of course, in complete agreement, but the majority find: that there are no differences between large and small classes in terms of student accomplishment, that large classes do not penalize the student and that, in some instances, students in large classes surpass those in smaller ones.

Studies of the effect of seating position (1, 2) on student grades agree that students in the front center of the room receive higher grades than those at the sides and rear.

The results of such investigations are suggestive but the conclusions derived from them can not be applied directly to the kindergarten situation, for in the first place the criterion as to what constitutes a large or a small group varies considerably from one study to another, (a "small" university class is often larger than a "large" kindergarten group) and furthermore the subjects chosen are pupils in the elementary and upper grades where the learning situation is a more strictly formal one.

The first part of the present study was concerned with the amount which kindergarten children retained from a single reading of a new story; the second part was concerned with the degree to which the children entered into a discussion of material presented to them for the first time. Both parts of the study were carried out in all the schools in which we worked.

For the first part of the study, the material used was a modified translation of "La Gironata de Titi," 992 words in length with 13 illustrations. The kindergarten teacher read the story to the group of children without comments or explanations except in so far as it was necessary to answer the children's questions. Such questions, however, were very rare. After read-

[1] From the Institute of Child Welfare, University of Minnesota. The writer wishes to thank Dr. Josephine C. Foster for her many valuable suggestions and the teachers of the cooperating kindergartens for their generous assistance which made this study possible.

ing each page of text, the teacher displayed the illustration accompanying that page.

The subjects used were 433 kindergarten children in nine Minneapolis public schools. Of the children, 190 attended the afternoon session (first semester) and 243 the morning session (second semester of kindergarten). The groups ranged in size from fifteen to forty-six children.

On a seating chart the observer recorded the position of each child. Row 1 contained those children who were next to the teacher, row 2 those who had one child between them and the teacher, etc. "Center" included the three vertical rows of children directly in front of the teacher. "Right" included those sitting outside of this section at the teacher's right; "Left" those at the teacher's left.

On the day following the reading of the story each child was questioned individually by the observer. In this examination the story was retold very briefly to the child with 7 questions on different episodes interrupting the continuity of the story. Colored paper dolls representing the characters in the story were shown to the child at this time to heighten interest. A correct answer was recognized with a "Yes, that's right" or "That's just what happened;" an incorrect answer was ignored unless it affected the rest of the story in which case the observer said "No, it wasn't quite that way" and then gave the correct version.

The child's score was computed by giving 2 credits for each correct answer, 1 credit for each partially correct answer and deducting 1 credit for each wrong answer. The possible range for total scores under this plan was from −7 to 14, but to avoid the use of negative scores 7 was added to each score, thus making the possible range from 0 to 21.

TABLE 1

Mean score on story for boys and for girls, AM and PM

	BOYS		GIRLS		BOTH SEXES	
	Mean score	Number of cases	Mean score	Number of cases	Mean score	Number of cases
AM group	12.24	126	12.25	117	12.37	243
PM group	11.25	91	11.69	99	11.48	190
Both AM and PM	11.82	217	12.14	216	11.98	433

The scores which the children actually received range from one to twenty-one with an average score of 11.98 ±3.84. The average scores for boys and girls and for morning and afternoon children are presented in table 1. In all instances the scores for the afternoon children fall slightly below those of the morning children. Although sex differences are practically negligible, the girls receive slightly higher scores. Figures 1a and 1b represent the frequency distribution of the scores for morning and afternoon, and for boys and girls. In general the scores fall into a normal curve of distribution.

Figure 2 shows the distribution of

average scores by size of group. Differences between the groups are small but there is an indication that the middle size groups have the higher scores. A rank order correlation of .37 shows that there is a slight positive the low afternoon scores. When size of group and average score are correlated for the morning groups the correlation drops to .10. The finding, then, of such a slight positive relation justifies only the conclusion that, in agree-

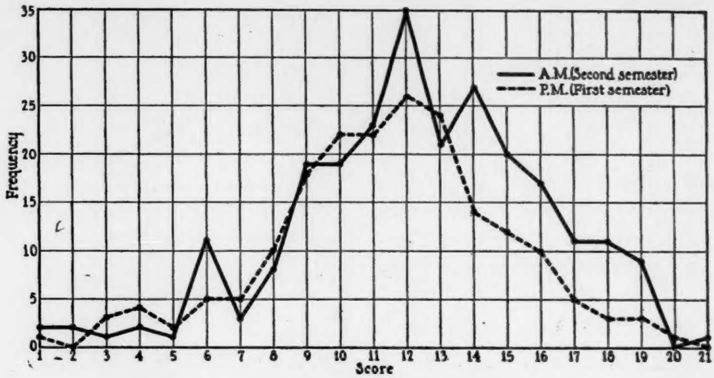

FIG. 1a. SCORES OBTAINED ON RECALL OF A STORY BY MORNING AND AFTERNOON SESSION

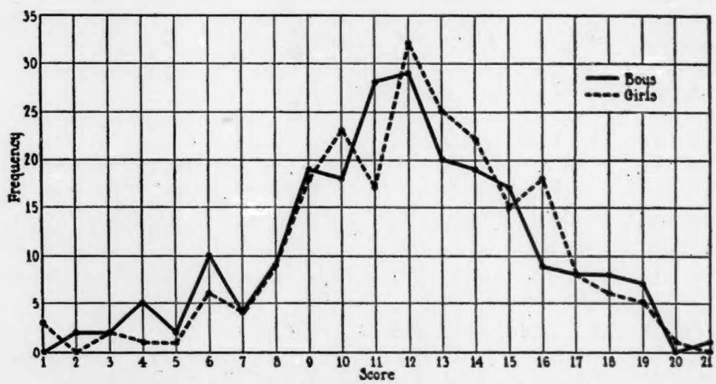

FIG. 1b. SCORES OBTAINED ON RECALL OF A STORY BY BOYS AND GIRLS

relationship between average score and size of group. However, since there are more small groups in the afternoon than in the morning and since the afternoon children receive lower scores, the correlation is unduly weighted by ment with the majority of studies reported in the literature, large classes do not penalize the scores of the members.

When the average scores are computed for the various positions within

the group the differences by row (shown in table 2) are again inconsistent and negligible; although the scores for the center position are slightly higher than those for left or right in both the morning and afternoon, the scores overlap considerably and the differences are so slight that no one position can justifiably be considered superior to the others.

To exclude a possibility that the greater number of small schools might be concealing a possible real difference between the extreme positions, the first two rows and the last two rows in the two largest schools were compared. In these schools 29 children sat in the front rows in the morning, 30 in the afternoon; 27 sat in the back rows in the morning, 30 in the afternoon. The

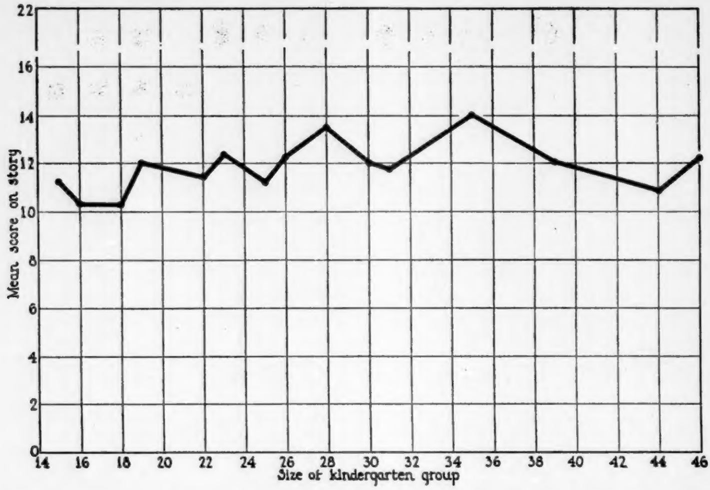

FIG. 2. DISTRIBUTION OF MEAN SCORES ON THE STORY BY SIZE OF KINDERGARTEN GROUP

TABLE 2

Mean scores on story by seating position

POSITION	MORNING GROUP			AFTERNOON GROUP		
	Mean	S.D.	Number of cases	Mean	S.D.	Number of cases
Row 1	12.74	3.02	53	11.14	3.78	50
Row 2	12.44	3.21	68	11.52	3.30	58
Row 3	12.26	4.25	65	11.79	2.95	42
Row 4	12.38	3.66	42	11.20	3.32	25
Row 5	11.27	3.45	15	12.07	3.45	15
Left Rows	12.23	4.09	83	11.31	3.14	52
Center Rows	12.49	3.23	106	11.65	3.59	83
Right Rows	12.37	4.05	54	11.38	3.32	55

average scores are slightly higher for the back two rows in the afternoon sessions (11.43 as compared with 10.86) while in the morning this relation is reversed (12.72 as compared with 12.48).

Certainly all the data warrant the conclusion that size of group may have a slight positive effect, while position in the group has no demonstrably consistent effect upon the amount of information the children retain after hearing a story read to the group. We may conclude that large and small groups offer an equal opportunity to learn this type of material and that individual differences in score are not affected to any great degree by the child's seating position. This finding agrees in general with studies of class size as reported in the literature, although these studies are concerned with a more formal type of learning and instruction and with older children, for the majority find either that class size has no appreciable consistent effect on learning or that children in large classes learn equally as well as those in smaller ones.

For the study of the effect of size of group and position within the group upon participation in discussion, we used a large brightly painted Noah's Ark containing eight pairs of animals three inches in height—elephant, cow, horse, pig, goat, bear, giraffe, and camel.

The teacher conducted a group discussion, stimulating conversation from the children by questions chosen from several possible leads suggested by us or by questions of her own. During the first ten minutes of the discussion the observer kept a record of the number of remarks contributed by each child. One word answers made in chorus were not recorded.

The subjects were 460 children in 17 groups ranging in size from fourteen to forty-six. Two hundred and three of the children were attending the first semester of kindergarten; 257, the second.

The average number of remarks per child for boys and girls, and for morning and afternoon children are given in table 3. Differences between morning and afternoon children are very slight and are not consistent. Interestingly enough the boys contribute more remarks than the girls.[2] This difference is more pronounced when the percentage of total number of remarks is computed. Table 3 also shows that the girls are more often silent than the boys. Whether this means that kindergarten boys are in general more talkative than are girls or that the material which we were using was more interesting to the boys, is not clear.

The differences in the average number of remarks per child according to size of group are presented in figure 3. Here there is a definite difference in favor of the smaller groups, for the smaller the group, the more remarks each child contributes. In a group of 14, for instance, the average number of remarks per child is 6.71, while in a group of 45 the average is only 1.20.

It is obvious that in a period limited

[2] Hall (3) in 1891, gave information tests to 200 five and six year old children. The boys excelled in knowledge of animals. Hall also reported that Hartmann, testing 1312 children from $5\frac{3}{4}$ to $6\frac{3}{4}$ years found that boys excelled in concepts referring to animals.

Probst (5) testing 100 children from 5.4 to 6 years found boys superior to girls in concepts of animals.

to 10 minutes the more children there are in the group the less opportunity there is for each child to contribute. Accordingly, as the group grows larger one or the other or both of two conditions may occur. Either a smaller percentage of the children in the group will have a chance to contribute within the time allowed; or, the total number of remarks will fail to increase proportionately to the increase in the number of children in the group simply because there is a limit to the total number of remarks that can possibly be made within a definite time, and when this occurs, of course, the average number of remarks per child will decrease as the size of the group increases.

The results of this study show both these factors operating: the larger the group the greater is the number of children talking (rank order correlation between number talking and size of group is .82), but the percentage of children who contribute lags behind the increase in size of group considerably (rank order correlation between percentage of children talking and size of group is −.58); at the same time the total number of remarks does not increase in proportion to the increase in size of group (rank order correlation between total number of remarks and

TABLE 3

Responses in discussion group

	Mean number of remarks		Per cent of total remarks made		Per cent of children saying nothing		Number of cases	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
AM	3.57	2.22	61.7	38.3	32.6	41.4	129	128
PM	3.25	2.71	52.3	47.7	36.1	37.7	97	106
Both AM and PM	2.90	2.97	57.5	42.4	34.1	39.7	226	234

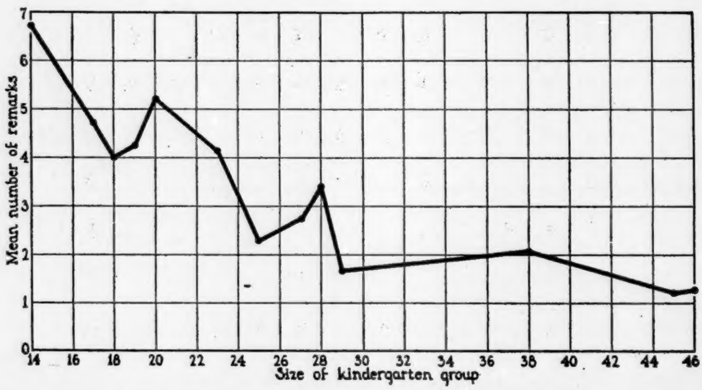

FIG. 3. MEAN NUMBER OF REMARKS PER CHILD BY SIZE OF KINDERGARTEN GROUP

size of group is −.14), and the average number of remarks per child in larger groups is too small to be accounted for entirely by the fact that the time limit for all groups was the same.

TABLE 4

Average number of remarks per child for each seating position

	AM			PM		
	Mean	S.D.	Number of cases	Mean	S.D.	Number of cases
Row 1	4.12	5.19	78	5.28	6.66	56
Row 2	3.06	4.03	70	2.44	2.92	61
Row 3	2.34	2.83	56	1.85	2.83	46
Row 4	1.60	3.50	40	1.42	1.65	26
Row 5	1.15	2.21	13	.36	.48	14
Left Rows	2.64	3.77	88	3.43	4.57	63
Center Rows	2.77	3.86	93	3.48	5.37	76
Right Rows	3.36	4.88	76	1.89	2.76	64

It must be borne in mind, of course, that the larger groups might not be penalized so greatly if the time during which records were taken had been increased, but the finding is, in effect, a practical one since not all can be given an opportunity to participate unless the discussion be so prolonged that it becomes fatiguing; as a matter of fact the usual discussion periods in the kindergarten program seldom last more than 15 minutes.

TABLE 5

Percentage of total remarks made in each seating position

(weighted for number of children in each row)

POSITION	PERCENTAGE OF TOTAL REMARKS	
	Morning	Afternoon
Row 1	34.2	49.4
Row 2	25.1	20.5
Row 3	18.1	15.3
Row 4	13.0	11.7
Row 5	9.6	3.0
Left Rows	30.2	38.8
Center Rows	31.6	39.5
Right Rows	38.1	21.5

TABLE 6

Percentage of children saying nothing in in each seating position

POSITION	PERCENTAGE SAYING NOTHING	
	Morning Group	Afternoon Group
Row 1	26.9	21.4
Row 2	37.1	32.8
Row 3	32.1	52.2
Row 4	52.5	38.5
Row 5	69.2	64.3
Left Rows	37.5	34.9
Center Rows	36.6	38.2
Right Rows	36.8	37.5

Many of the kindergarten teachers reported they usually found it more difficult to elicit conversation from a small group. In a larger group the remarks of the other children stimu-

late conversation, while in a small group the teacher has to stimulate a greater share of the conversation herself. Our results, however, show that there is a slight tendency for a greater amount of discussion in the smaller group. It may be more difficult to initiate the discussion, but once started the children in a small group, at least in so far as a discussion of this type is concerned, talk more than those in a large group.

When the results are tabulated by the child's position in the group, we find a consistent tendency (though there is overlapping) for the number of remarks to decrease the further the child is seated away from the teacher (table 4). When the number of remarks made in each row is expressed as a percentage of the total number made in the group (table 5) (allowance made for varying number of cases) we see that over a third of the remarks are made by children sitting in the first row, while those in the last row contribute a tenth or less. When the data are tabulated according to the number of children who make no contribution at all to the discussion, the same tendency is apparent (table 6). Thus, 69.2 per cent of the children in the last row are silent, whereas only 26.9 of the children in the first row say nothing. The corresponding figures for the afternoon children are 64.3 and 21.4.

The differences between left, center and right are inconsistent and so slight that the only conclusion justified is that, under our conditions at least no one position is more advantageous than another.

TABLE 7

Changes in seating positions on successive days

	DISTRIBUTION OF CHILDREN ON THE TWO DAYS				
	Row 1	Row 2	Row 3	Row 4	Row 5
Story-day	24.8%	29.4%	24.3%	12.6%	6.3%
Discussion-day	30.6	28.9	21.6	11.6	4.6

	PERCENTAGE SHIFTING THEIR POSITION ON THE SECOND DAY				
	No rows	1 row	2 rows	3 rows	4 rows
Morning group	24.5%	42.2%	24.5%	6.0%	2.5%
Afternoon group	29.0	41.9	22.3	5.5	1.1

It is possible that the talkative child tends to sit in front while the reticent, less assertive child chooses or is content with a seat in the rear of the group. Our records of seating position on two different days show that more children sat in the front row for discussion than for the story, suggesting that when certain children realize that new material is to be shown, they move nearer the front. The percentages of children sitting in different rows for the story and for the discussion are presented in table 7. Generally speaking, however, the children's positions

are relatively stable with an average shift of not more than one row. The average change in position and the percentage of children shifting according to number of rows moved are given in table 7.

In summary, we may say that increase in size of group in the kindergarten (at least between the limits of fourteen and forty-six) does not reduce the amount of a story which was retained by the children, but that increase in the size of the group means a cutting down in the percentage of children who take part in a discussion, in the total amount of discussion and in the average number of remarks per child. Position in the group apparently does not influence the amount of a story, which these kindergarten children retain but does affect the extent to which they enter into a discussion.

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A Tentative Report of the Influence of Nursery School Training upon Kindergarten Adjustment as Reported by Kindergarten Teachers[1]

Hazel M. Cushing

THE attempt to justify education in the nursery school by demonstrable quantitative evidence is attended by the same difficulties as is similar proof of the existence of permanent values inherent in education at any other level. Educationists produce triumphantly the achievement or educational test as evidence that educative process lends itself to the test of scientific measurability. This, in spite of the obvious shortcomings of such a type of measurement, namely (1) that much of the factual knowledge so measured is for all practical purposes lost in succeeding years, (2) that the value of such facts as are inculcated in relation to the subsequent problem of living has never been quantitatively gauged, (3) that even if later value to the individual should yield to indubitable proof, more economical learning processes might be substituted for the long drawn out, expensive, and frequently painful road adopted by the formal educationists, and finally (4) that of the half dozen or more objectives set up as educational goals, and presumably of approximately equal importance, the achievement test measures but one, namely, intellectual acquisition. Growth in social adaptability, emotional control, inner poise and serenity of spirit, ability to deal with new situations, to solve the complex problems of living, health, initiative, as well as the factors that go into the elusive item termed 'good citizenship,' all rest obscurely up to date in the limbo of speculation.

Despite such obvious limitations in attempts to measure the results of the schooling process in general, nursery school proponents must, nevertheless, join other educators in an attempt to test educational values accruing from a specific type of training. Only thus can education at the nursery school level justify its membership in the educational family as well as defend itself against all too glibly-hurled charges of faddism.

There have been few attempts to measure the effects of nursery school training. In the studies reported it

[1] Acknowledgment is made to the members of the child development staff, Miss Harriet Stillman, Assistant Director of Elementary Grades and Kindergartens, and the various kindergarten teachers who rated the subjects, Dr. Ruth Hubbard and to Miss Olive Young, who tabulated the material.

has been the traditional or mental values of training which have been most frequently investigated—not, to be sure, in the sense of educational tests of formal subject matter which has no place in the preschool curriculum, but in relation to the quantitative and qualitative changes in mental capacity.

Goodenough, Barrett and Koch, Woolley, Updegraff, Wellman, Kawin and Hoefer[2] have reported investigations of this type. Although the evidence is somewhat conflicting, the net result to date yields no support of the theory that nursery training *per se* affects permanent changes in the mental status of the recipients of such training.

As to the effect of nursery school training upon health and personality, there is even less available material, due, no doubt to the difficulties of isolating such intangibles and to the lack of suitable standardized measuring instruments.

Comparing 470 records of nursery school children from two to six years of age with reports from three control groups, Updegraff (6) came to the conclusion that the nursery school which furnishes adequate daily health inspection reduces the incidence of communicable diseases. In other words, that "a school group so conducted is a more favorable environment to prevent contagion than the home ordinarily is." The specific diseases studied were chicken pox, measles, mumps, scarlet fever, and whooping cough.

Campbell (2) studied the food habits of 33 children enrolled in the Merrill-Palmer Camp, 18 of whom had had nursery school training. The children ranged in age from 6 years to 13 years and 5 months. A Food Habits Rating Scale was devised in accordance with Thurstone's procedures. There appeared to be little difference in the food habits of the two groups. There was some evidence that the nursery school group ate more milk and vegetables. There was also some indication that the children who had attended nursery school most recently evidenced the better food habits. Food habits of siblings were more strikingly alike even when one of a pair had attended nursery school, than were resemblances between nursery school children in general. Hence the conclusion is that the home is a much more important factor than the nursery school in forming food habits and attitudes.

Walsh (7), using the Bonham-Sargent Scale, tested a group of 22 nursery school children over a period of 6 months. Compared with a similar group of controls, the experimental group became less inhibited, more spontaneous and more socialized with training. They developed greater initiative, independence, self-assertion, self reliance, showed a greater increase of curiosity and interest in their environment, and developed superior habits of health and order.

Taylor and Frank (5) of the Illinois Institute for Juvenile Research investigated follow-up techniques for former nursery school children employed in nineteen centers. They reported that in 1931 only 2 institutions, the University of California and

[2] See appended references.

the University of Minnesota, appeared to have developed a well-defined plan of follow-up. They also gave a preliminary report of their own follow-up study of 38 children who have been in nursery school at least one year. At the time of re-examination most of the children were more than six years of age—a few had gone as far as the third grade. The follow-up consisted of physical and psychological retests, and ratings by mothers and teachers. These investigators felt that difficulties encountered and the small number of cases did not warrant any valid conclusions. Personality difficulties such as temper tantrums and negativism noted as of frequent occurrence by the nursery school teacher appeared rarely to be present in the elementary school. They suggest as a possible explanation either that a large group and the impersonality of the teacher's attitude tends to discourage such displays, or that due to pressure of work, the teacher is less likely to observe such phenomena.

The preliminary study herein reported concerns the adjustment of nursery school children to the kindergarten situation as estimated by kindergarten teachers. Frequent fears have been voiced by kindergarten teachers and also by parents to the effect that children experiencing nursery school might be 'spoiled' for kindergarten, that they would be more or less blasé because of the similarity of materials presented at both levels, that the greater freedom granted in the nursery school environment would militate against coöperative behavior in the more restricted and directed atmosphere of the kindergarten, that parents would be less satisfied with the kindergarten régime, that they would tend to expect much more personal consideration for themselves and their children than is possible for the kindergarten teacher to grant in view of the large number of children committed to her care.

The subjects. Over a period covering approximately two years it was possible to get teacher ratings on 33 children, 10 boys and 23 girls, who had received training in a demonstration nursery school in session from 8:30 a.m. to 3:00 p.m. The average nursery school attendance for the group as a whole was 172 days, the range from 81 to 326 days. Intelligence quotients based upon the Kuhlman-Binet Test[3] ranged from 93 to 150 with the mean at 120.

Practically all of the families involved ranked in the upper 50 per cent of the population in respect to socio-economic status. In general, the children upon leaving nursery school attended public schools in the better residential sections of the city. Hence the assumption is made that they were received into kindergarten groups of fairly similar social status.

There were, however, two observable discrepancies between the nursery school and the non-nursery trained kindergarten children. The former averaged four months younger than the latter in respect to C.A., the mean ages being 55 months and 59 months, respectively. The difference is statistically significant.

As has been stated above, the average intelligence quotient for the

[3] In all but two instances.

nursery school group was 120. Composite ratings based upon intelligence tests and teachers' estimates, general adjustment and maturity were available in the case of ten nursery school children who had passed into the first grade. In eight cases, the nursery school children ranked in the upper quarter; in two, in the upper half of the second quarter. It is thus apparent that with respect to intelligence the nursery school group as a whole probably ranked above the average of the kindergarten groups in which they were placed. Reference will be made to this point later in connection with the 'control' group.

The raters. Adjustment ratings were made by nine different teachers. Nineteen children, however, were rated by 2 teachers only, 3 teachers rated but one child so that the scatter in respect to raters is not large as would appear at first glance. Each teacher was asked to rate the nursery school child from not less than three to more than six weeks after his entrance to kindergarten and to send the blank immediately to the Child Development office. Without reference to her first rating, she was then asked to rate the child a second time at the close of the semester. Samples of typical behavior responses were grouped under the headings *Health Habits, Social Adaptability, Use of Environment,* and *Personality Traits.* The teacher was asked to check each one of these responses in two ways, first, as to the frequency of its occurrence, in terms of *always, usually, frequently, seldom,* or *never,* and second, as to whether the behavior noted was *poorer than, better than,* or *average* with reference to the typical behavior of the group as a whole.

In addition the teacher was asked to check the item most descriptive of the child's response to the kindergarten environment as follows: *enthusiastic, interested, indifferent, bored, rebellious.* She was also required to evaluate the child's adjustment on the whole, whether *better, poorer* or *average* as compared with that of the group. She also listed kindergarten activities which the nursery school child appeared to enjoy most and the materials he used most frequently and with greatest interest. She was asked to report as to whether the mother expected an undue share of attention for the child.

The complete progress blank[4] is given on pages 312 to 314.

Twenty-seven cases were rated both at the beginning and at the end of the semester, 4 were rated at the beginning only and 2 at the end only.

Table 1 gives the percentages of occurrence for both the first and second ratings, together with results on a control group of 25 kindergarten children to be referred to later. In translating the items listed under *personality traits* in terms of desirability, it must be borne in mind that the less frequent the occurrence, the more favorable the behavior. The opposite is the case in the three other categories, health habits, social adaptability, and use of environment, where a high frequency of the behavior items indicates desirable responses.

Differences between first and second ratings are noticeably small. This would seem to argue either for a

[4] Items were taken in part from records used at Merrill-Palmer School, University of Minnesota and the article by Taylor and Frank referred to above.

certain reliability in the ratings or to indicate that teachers have a certain generalized attitude toward children in the kindergarten in which the nursery school child shares. There is, however, a small but consistent trend toward a better rating on the second blank in all of the four categories. This may indicate (1) that the teacher has through a longer acquaintance had more opportunity to observe the child's responses, (2) that real learning has taken place during the semester, or (3) that the child has become somewhat more of a conformist, owing to the social pressure put upon him in the new environment.

Table 2 indicates the extent to which the behavior of the nursery school children accords with that of the group. Results for the control group are also given for the sake of convenience. Less than 20 per cent of the ratings are below the average adjustment. Approximately 10 per cent fall in the high group, the majority of ratings lie in the average group.

The general ratings which indicate the teacher's impression of the child as a whole given in table 3, substantiate the itemized ratings except that more nursery school children are rated better than average, the per cent being approximately 20, as against 10 per cent indicated in table 2. These figures may indicate the tendency of raters to avoid extremes. In any case, however, they do not seem to warrant the assumption that the nursery school child adjusts with great difficulty to the demands put upon him by the kindergarten environment.

It was possible to check in a

TABLE 1

Frequency of occurrence ratings in terms of percentage

	ALWAYS	USUALLY	FREQUENTLY	SELDOM	NEVER	NOT REPORTED
Health habits:						
Rating I	27	39	11	13	1	9
Rating II	37	29	13	7	2	12
Control	49	24	6	6	2	13
Social adaptability:						
Rating I	38	26	19	10	4	3
Rating II	38	32	18	8	3	1
Control	51	22	12	9	4	2
Use of environment:						
Rating I	31	26	12	19	10	2
Rating II	42	27	15	13	3	0
Control	43	22	11	16	8	0
Personality traits:						
Rating I	1	2	7	10	60	20
Rating II	1	2	12	16	51	18
Control	1	1	4	8	74	12

measure the validity of the general ratings. Each child was rated separately on a five point scale by the two nursery school teachers who knew him best in respect to his general related against the total adjustment ratings of the kindergarten teachers. There was a fair degree of agreement (r = .37 ±.10) between the kindergarten teachers' general estimate of

TABLE 2

Comparison of behavior of nursery school children with kindergarten group as a whole in respect to the four categories in terms of percentages

	LOWER	AVERAGE	HIGHER	NOT REPORTED
Health habits:				
Rating I	5	74	11	10
Rating II	7	72	7	14
Control	9	71	7	13
Social adaptability:				
Rating I	19	66	12	3
Rating II	19	70	11	0
Control	18	63	17	2
Use of environment:				
Rating I	26	64	7	3
Rating II	18	69	13	0
Control	29	59	11	1
Personality traits:				
Rating I	8	55	11	26
Rating II	1	57	16	26
Control	0	78	10	12

TABLE 3

Comparative adjustment ratings in terms of percentages

	BETTER	AVERAGE	POORER	NOT REPORTED
Rating I	26	52	22	0
Rating II	21	62	14	3
Control	28	44	28	0

adjustment to the nursery school situation. Intercorrelation between these two pairs of ratings were .903 ±.03 and .74 ±.07 respectively. The average ratings were then correlated against the total adjustment ratings of the kindergarten teachers.

the child and that of the nursery school teachers.

No nursery school child was rated as bored or rebellious in his attitude toward the kindergarten either during the initial period or at the end of the semester. Practically all were rated as 'enthusiastic' or 'interested.' Table 4 presents these ratings in terms of percentages.

Ten per cent only of mothers were found to be inconsiderate in their demands upon the teacher's time.

In order to check further the validity of the ratings the same teachers were asked to rate approximately

the same number of non-nursery school children. They were asked to pick the younger children in the group in order to equalize the factor of age as nearly as possible. For administrative reasons ratings had to be secured before the end of the semester. It was possible to secure only one rating for this group. This was not considered a serious handicap, however, since the earlier part of the study indicated considerable conformity between first and second ratings. Twenty-five cases, 10 boys and 15 girls, comprise the control group. Attendance in kindergarten for this group averaged 27 days.

TABLE 4

Response to kindergarten situation in terms of percentages

	ENTHUSIASTIC	INTERESTED	INDIFFERENT	BORED	REBELLIOUS
Rating I	42	55	3	0	0
Rating II	59	41	0	0	0
Control	40	44	16	0	0

TABLE 5

	DAYS OF ATTENDANCE		CHRONOLOGICAL AGE		INTELLIGENCE QUOTIENT	
	Range	Mean	Range	Mean	Range	Mean
Nursery group rating 1	9–36	20.7	45–64	55.4	93–150	120
Nursery group rating 2	50–88	71.7	55–66	59.6	93–150	120
Non-nursery control	16–35	27.3	58–60	59.5	75–129	107.3

Table 5 shows in comparison number of days of attendance, the chronological ages and intelligence quotients of the two groups.

A comparison of ratings indicates a slight superiority for the control group in Health Habits, Social Adaptability, and Personality Traits. In Use of Environment nursery school children excel slightly on the second rating. Refer to table 2. When the teacher rates the behavior as low, average, or high in comparison with that of the group, however, the situation is reversed and the nursery school group maintains a slight superiority in all categories. (Refer to table 3.)

The attitude of the non-nursery mothers shows that 12 per cent expect the child to receive an undue share of the teacher's attention as compared with 10 per cent of the nursery school mothers.

Few differences appeared between the two groups in regard to the use of materials or choice of activities. Blocks, crayons, paper, paste, plasticine, scissors and sewing appeared popular with both groups. It is significant, however, that both in regard to the amount of material used and total number of activities

TABLE 6

	RATING I	RATING II	CONTROL
Number of materials listed	69	67	54
Number of activities listed	55	56	33

listed the nursery school exceeded the control group considerably. Total number of choices is indicated in table 6.

Summary. In this preliminary study of the adjustment of nursery school children to kindergarten there would seem to be no evidence that the nursery school trained child makes an inferior adjustment to kindergarten, despite his handicap in chronological age. The 33 children rated were about 4 months younger on the average than the kindergarten group with which they were placed. Although intelligence quotients were not available for the kindergarten group as a whole, it is probable that the nursery school group were superior in this respect, since only two children out of ten ranked in the normal group, the rest having intelligence quotients above 110.

When compared with a group of non-nursery kindergarten children of similar chronological age, no striking differences were observed. The nursery school group, however, did appear to be rated somewhat superior in their total adjustment to the situation and considerably more so in general attitude.

Mothers of nursery school children do not appear to be more demanding of kindergarten teachers than mothers of non-nursery trained children.

Derogatory remarks concerning the adjustment of nursery school children to kindergarten on the part of kindergarten teachers may frequently emanate from experiences with isolated cases to which any of the following factors may be contributory:

1. The lower chronological age of the nursery school child combined frequently with high intelligence—such a child tends to present a problem in a conventional school group at any level.
2. The freedom and lack of restriction in the nursery school which may run counter in some instances to the greater conformity demanded in the kindergarten.
3. The use of initiative stressed in nursery school as against passive participation in the more directed types of activity of the kindergarten.
4. The fact that it is highly probable that a selective behavior factor influences enrollment in the nursery schools, that is, a higher proportion of 'difficult' children probably find their way to nursery schools as they are set up at present.
5. A certain antagonism and distrust of the nursery school on the part of the kindergarten teacher, so that she may unconsciously be more highly critical of the nursery trained child.
6. The fact that the term 'nursery school' is used at present to convey a variety of situations and a varied length of training. There is a current tendency to loosely characterize any child who has ever attended any sort of preschool group for any length of time as a 'nursery school' child.

Certainly much research is needed before facts can be stated with any degree of finality in regard to the effect of nursery school training upon the subsequent progress and adjustment of the child.

PROGRESS BLANK

CHILD DEVELOPMENT AND PARENT EDUCATION

ROCHESTER, NEW YORK

Date........................

Child's name..

Address...

Father's name..............................Mother's name...............................

Nursery school...

Address of nursery school...

Attended from..................................to.................................

(date and year) (date and year)

Total attendance in nursery school................days. Public school number........

Total attendance in kindergarten..................days. Age entered kdgtn...........

Kindergarten teacher...

Go through the questionnaire and check Column I.

Then go through it a second time and check Column II.

Method of Scoring

Column I

A—child *always* expresses behavior.
U—child *usually* expresses behavior.
F—child *frequently* expresses behavior.
S—child *seldom* expresses behavior.
N—child *never* expresses behavior.

Column II

L—child exhibits behavior in *less* degree than average of group.
A—child exhibits behavior corresponding to *average* of group.
H—child exhibits behavior in *higher* degree than group.

Check all items somewhere on the scale but put a question mark (?) after judgments of which you are not sure.

	Column I					*Column II*		
HEALTH HABITS	*A*	*U*	*F*	*S*	*N*	*L*	*A*	*H*
Uses handkerchief when needed........................	—	—	—	—	—	—	—	—
Protects others when sneezing or coughing............	—	—	—	—	—	—	—	—
Attends to toilet needs independently................	—	—	—	—	—	—	—	—
Washes hands after toilet............................	—	—	—	—	—	—	—	—
Washes hands before handling food....................	—	—	—	—	—	—	—	—
Refrains from putting objects to mouth...............	—	—	—	—	—	—	—	—
SOCIAL ADAPTABILITY—EMOTIONAL BEHAVIOR								
Seeks companionship with other children..............	—	—	—	—	—	—	—	—
Coöperates in group projects.........................	—	—	—	—	—	—	—	—
Gives creative suggestions in group activities.......	—	—	—	—	—	—	—	—
Respects rights of others............................	—	—	—	—	—	—	—	—
Is kind and helpful to others........................	—	—	—	—	—	—	—	—
Adjusts readily to new situations....................	—	—	—	—	—	—	—	—

Shows a reasonable degree of self control in conflict with others	— — — — —	— — —
Appears happy and content in school environment	— — — — —	— — —
Is willing to accept authority when occasion demands	— — — — —	— — —
Is satisfied with normal amount of attention from teacher	— — — — —	— — —
Refrains from seeking undue attention from children	— — — — —	— — —
Exhibits independence in putting on wraps	— — — — —	— — —
Accepts correction in good spirit	— — — — —	— — —
Is liked and included in group activities	— — — — —	— — —
Shows a willingness to share	— — — — —	— — —
Refrains from baby talk	— — — — —	— — —
Is free from other speech difficulties	— — — — —	— — —

USE OF ENVIRONMENT

Exhibits initiative in undirected activity	— — — — —	— — —
Exhibits initiative in directed activity	— — — — —	— — —
Has sustained attention until task is completed	— — — — —	— — —
Shows curiosity and interest in surroundings	— — — — —	— — —
Is creative with materials in environment	— — — — —	— — —
Shows reliability in care of materials	— — — — —	— — —
Displays ability to lead	— — — — —	— — —
Displays ability to follow	— — — — —	— — —
Runs with ease	— — — — —	— — —
Skips with ease	— — — — —	— — —
Hops with ease	— — — — —	— — —
Handles tools and materials well	— — — — —	— — —

PERSONALITY TRAITS

Check the degree to which the child shows the following behavior:

Crying	— — — — —	— — —
Sulking	— — — — —	— — —
Pouting	— — — — —	— — —
Temper tantrums	— — — — —	— — —
Negativism	— — — — —	— — —
Fighting with other children	— — — — —	— — —
Teasing	— — — — —	— — —
Selfishness	— — — — —	— — —
Whining	— — — — —	— — —
Cruelty	— — — — —	— — —
Tenseness	— — — — —	— — —
Timidity	— — — — —	— — —
Secretiveness	— — — — —	— — —
Seclusiveness	— — — — —	— — —
Distractibility	— — — — —	— — —
Self-consciousness	— — — — —	— — —
Attacking other children	— — — — —	— — —
Destructiveness	— — — — —	— — —
Day dreaming	— — — — —	— — —
Emotional instability	— — — — —	— — —
Enuresis (diurnal)	— — — — —	— — —
Finger sucking	— — — — —	— — —

Masturbation.......................... —————— ———
Nail biting.............................. —————— ———
Nose picking........................... —————— ———
Hyperactivity........................... —————— ———

List any other undesirable personality traits shown by the child:
....

Check the term which best describes the child's response to the kindergarten situation:
Enthusiastic........Interested........
Indifferent........Bored........Rebellious........

Kindergarten teacher's own evaluation of the nursery school child's adjustment:

On the whole:

(1) Does the child show a better or poorer adjustment to the kindergarten environment than the average kindergarten child?..............................
....

(2) What activities does the child appear to enjoy most?...................
....

(3) What materials does he use most frequently and with the greatest apparent interest?...
....

(4) Does the mother expect the child to receive more than his share of attention?...
....

Additional remarks:
....
....
....

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Children's Motor Learning With and Without Vision

Ruth Taylor Melcher

THE PROBLEM

WHETHER data from the visual processes or from tactual-motor manipulation are predominant in the acquisition and performance of skilled acts has been investigated by various methods with animal and adult human subjects, but there have been few attempts to study the relationship directly in the early stages of ontogenetic development. The specific problem of this experiment is the determination of the relative effectiveness of visual versus manual cues in the motor learning of young children.

Since motor learning ordinarily consists of a series of spatial coördinations, the ultimate problem involves the relative importance of visual and tactual-motor sentienda in the organization of our spatial perceptions. The question is whether stimuli from the visual processes (including all the kinesthetic sense data from eye-movements) are in themselves sufficient and initially dominant in producing spatial ideas and appropriate motor responses, or whether the sensory receptors in the responding organ itself must give the stimulus initially. In the latter case there are two alternatives: either these spatial coördinations, learned only through manipulation, guide and educate the visual perceptions, or the two systems are entirely independent originally, and become coördinated only through their association in use.

Prior to Berkeley, vision and touch (including movement) were held to be practically interchangeable sense modes. Berkeley (1) was the first to draw a sharp distinction between the reports of the two senses, and to contend that notions of space are not intrinsic to vision, but are built up through the movement and tactual experience of the individual. This theory directed attention to the experiences of those born blind, who later gained their sight through operation. This literature has been critically reviewed by von Senden (31), who came to the conclusion that the blind have no true spatial consciousness, but that this is bound up with visual perception. None of the observations on the blind were experimentally controlled.

The difficulty in arriving at any conclusion as to the origin of space habits in normal human adults obviously lies in the fact that they are already formed long before it is possible to bring them to the laboratory. To overcome this disadvantage, some investigators have attempted to break up the habits formed and observe new ones in formation through distortion

of the visual world by means of prismatic lenses.

Stratton's (32) pioneer work with a monocular lens reinverting the retinal image led him to the conclusion that visual direction was not dependent upon tactual direction. Wooster (38), following Stratton's method, found that visual perception of the amount of error was the most helpful single factor in mastering a new space habit, and was as efficient as the tactual and kinesthetic factors combined in active touch. Ewert (11) agreed as to the primacy of visual receptors in spatially coördinated activity within the field of vision. He emphasized the typical motor learning curves of his subjects and contended that the process of reëducation after distortion of the visual field consisted simply in learning by trial and error to readjust motor behavior to new visual cues, rather than in any change in reference of the sensory data. Contrary to Wooster, however, he found that readjustment occurred where there were no overt localizing movements, although he admitted that gross adjusting movements might be replaced here by eye and head movements and by those involved in verbal activity. Finally he pointed out the influence of instruction and the ability of the human subject to inhibit sense data from receptors which might distract from the task in hand.

Recently Cutsforth (6) has demonstrated by an interesting technique the discrepancy between the visual and tactual-motor perception of spatial relationships, and the difficulties in translating tactual-motor sense data into visual terms.

Results obtained with rats have proved suggestive of problems involved in human learning. Watson (36) concluded, after extensive experiment, that the learning of rats in a maze was entirely dependent upon kinesthetic cues, each movement being the cue for the following one. Hunter (13, 14, 15, 16), Lashley and Ball (20), Dennis (8), Macfarlane (22), and Dorcus and Gray (10) have called in question the adequacy of this theory, although the rôle of vision was not specifically investigated. Perrin (23), one of the first to test blindfold human adults both with pencil and paper mazes and in an outdoor circular walking maze found that ability to run the maze developed with the ability to describe it verbally and graphically and concluded that human maze learning was perceptual and ideational rather than sensory.

Weaver and Stone (37) and Lindley (21) found that the performance of blind, anosmic, and blind-anosmic rats in a maze differed very little from that of seeing animals, but just after Watson had popularized the proprioceptive theory, Florence Richardson (30), working in his laboratory, found that blind animals were at a decided disadvantage in learning to solve certain problem box situations and to jump from one small platform to another. Subsequently Dennis (8) and Walton (34) showed that when the experimental arrangements in the maze were such that vision could be used to advantage, the animals depended predominantly upon visual cues.

All studies of the effect of vision in adult human maze learning have shown that visual aid greatly reduces errors,

especially in the initial stages of learning. Brown (2, 3) whose subjects walked through a maze made by wooden troughs laid on the floor, found that persons allowed to see the ceiling and upper part of the doors and windows learned in fewer trials than those blindfold. His findings disagreed with Perrin's, however, in that the subjects were not able to draw or describe the maze after they had learned it.

The stylus maze has been the most frequently used instrument for the study of adult learning. Carr's (4) invention of the slot maze and his elaborate studies of the effect of visual guidance by this means all confirmed the effectiveness of visual aid in motor learning for adults. Carr and Osbourn (5) found that vision during the initial trials reduced both the errors and the trials, although errors more than trials. In three of four cases, the effect was even greater during the post-visual period than during the visual. Peterson and Allison (24) achieved results similar to Carr's when the visual exposure of the maze was measured by time instead of by number of trials.

Koch and Ufkess (19) found that seeing subjects were superior to blind subjects in learning a stylus maze. This was contrary to a priori opinion, since the situation seems analogous to the usual learning methods of the blind. Moreover, those who had once had sight did better than those who had been blind from birth, the intelligence level being, of course, the same. Contrary to these results, Knotts and Miles (18), comparing the maze learning ability of blind and seeing individuals from twelve to twenty-two years of age, found the blind superior by all criteria. Examination of the authors' graphs, however, shows that the differences were very small, and the more successful learners among the blind were those whose blindness was due to accident after five years of age.

Twitmyer (33) found that subjects who casually watched another person learn a maze, without expecting to learn it themselves, did better in the early stages of learning than the blindfold subjects, though a higher efficiency was attained in less time by the blindfold practice. Time was the only criterion of learning in this study, however, and error analysis might have given different results.

The preceding studies seem definitely to establish that the adult depends to a very great extent upon visual guidance in his ordinary motor learning. But the question remains whether this is the last stage of a development which began with dominance of tactual-kinesthetic cues. The assumption has often been made that children begin with dominance of kinesthesis in the responding organ and gradually shift to visual dominance, possibly substituting the kinesthesis of eye movements, at about puberty. Investigations of sensitivity to tactual stimulation in children and adults, both blind and seeing, by Renshaw, Wherry and Newlin (26, 27) and of primitive tribes by Rivers and McDougall (see 27) have been interpreted as substantiating this theory. Inspection of the data, however, throws some doubt upon these conclusions. De Sanctis' (9) maze experiment also indicated a shift, though at a somewhat earlier age.

Rice's work with young children is

in some respects the direct antecedent of the present study. Incidental to her investigation upon "The orientation of plane figures as a factor in their perception by children," (28) she found that success in reproducing a figure, whether from the model or from memory, was more closely related to perceptual development than to motor control. This the author cites as interesting "in view of the axiom derived from the response hypothesis that accuracy of motor response is a basis for accuracy of perception and later of thought." (28 p. 141) There is the possibility of the interpretation that perceptual development is responsible for the level of motor coördination.

Rice's third study (29) was an attempt to discover and analyze eye and hand movements occurring during an act of perception. Her subjects were 10 pairs of twins between 4.6 and 7.10 years of age. After a series of initial tests in which the child's eye and hand movements were recorded while he looked at a geometrical figure and his ability to reproduce it on a blackboard was tried, one of each set of twins was given a training course. Five children watched a bright yellow knob which traveled mechanically around a diamond shaped path on a black background. The other five children followed the knob with their hands but were not allowed to see it. There were nine ten-second trials in all, three at a time one day a week. Automatograph records of the hands were taken and the eye movements photographed on the first and last trial. The control group during this period only looked at the original card representing the diamond.

The author found "no transfer effect of any kind from imposed practice of eye and hand movements on eye and hand movements of an unrestrained nature used during observation of plane figures." The synchronized records of eye and hand movements showed no relation between them, either initially or after practice. There was a practice effect in the specific activity undertaken during the practice periods, i.e. the child learned to follow the moving knob. There was also "a possible transfer effect of this practice on the rather indefinitely defined activity of drawing the figure observed." (29, p. 47) Even the last mentioned positive results are questionable. However, the interesting point for the present study is that four of the instances of possible gain were from the five children subjected to eye training, while only two were from the five given hand training.

The results of this experiment, in conjunction with the previous finding that reproduction of a figure was related to perceptual rather than motor developmental level, suggest that visual data are dominant over those from other receptors in the education of eye-hand coördinations in the young child.

II. APPARATUS

Choice of apparatus for the experiment presented difficulties for several reasons. The problem required (1) that visual and manual cues be equated in manner of application, (2) that they might be given separately, and (3) that there should be a test of their relative effect.

Rice's (29) apparatus met the requirement of separate hand and eye

training, but her method of testing by drawing the diamond introduced many new factors into the reproduction situation. As her own results showed, the ideal situation would be one in which the child was shown how to do a thing, and then asked to do exactly that thing. This ideal was not entirely realized, but a closer approach was attempted.

After some preliminary experimentation with maze patterns, a block design was selected. This was similar to Dasheill's (7) in his study of direction orientation in the rat in that it was a block pattern with no culs-de-sac other than the edges of the maze. Converted into a slot maze, similar to that designed by Carr (4) and popularized by Young (39) in the "Boy and Shoe" model, it furnished an instrument in which the child might watch a stylus travel a chosen path through the blocks, and then be asked to guide a similar stylus through the same path in an identical maze. Similarly, his hand could be guided through the path without accompanying vision, and the relative value of these two methods of guidance compared as to their effectiveness in the ability to reproduce the pattern. This study was not concerned with the relative value of guided and unguided learning, but only with the relative effectiveness of two methods of guidance.

A preliminary study with 15 children between the ages of three and five years showed that the task offered sufficient difficulty for differentiation.

While the "game" pleased most of the children at first, it soon became evident that some reward was necessary to insure continued effort. An animal cracker at the end of the test maze, concealed in a small box which opened when the child was successful, proved to be of lasting interest.

Figure 1 shows a surface view of the mazes. They were of hard wood, built up in layers. They were both 39 by 39 cm. square, with a solid border on a level with the top surface of 6 by 6 cm. blocks. The bases of the two were solid boards, 24 mm. thick.

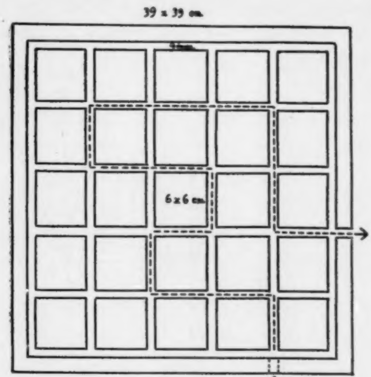


FIG. 1. SURFACE VIEW OF MAZE
The dotted line indicates the path traveled by the knob on the practice maze.

The practice maze had for its second layer two boards, 12 mm. thick, which were separated along their facing edges by 17 mm. This line of separation followed the dotted line shown in figure 1, forming the desired maze pattern. Similarly, two boards, 13 mm. thick, formed the third layer, separated along the pattern line by 9 mm. Thus the edges of this groove overhung those of the second layer 4 mm. on either side. In addition, grooves 6 mm. deep were cut in the top surface of these boards to form a block pattern. The top layer was of

blocks 13 mm. thick, carefully fitted to the surface blocks of the third layer. When complete the pattern groove was 38 mm. deep, while the depth of the remaining grooves was 19 mm. The whole was painted a rich blue, and the lighting arranged from the side so that the grooves were in shadow and the difference in depth was indistinguishable to casual examination.

The floor and sides of the wide groove in the second layer were lined with sheet tin, and a Singer sewing machine belt 8 feet long was inserted, the ends projecting through holes in the maze side at the points indicated by arrows in figure 1. The corners against which the belt rubbed were rounded and brass rollers inserted.

A stylus 69 mm. high was attached to the belt, with brass disc roller guides, 11 mm. in diameter, above and below the point of insertion. The knob of light yellowish composition was 12 mm. in diameter, 24 mm. high, and extended 31 mm. above the surface of the practice board.

In starting position, the knob stood at the edge of the board in the groove indicated by the arrow in figure 1. The end of the belt extending through the exit was hooked to a shaft revolved, through a reduction gear, by a synchronous motor, and as the belt was wound the attached knob traveled the indicated path, requiring 17 seconds to reach the exit. The mechanics are shown in figure 2. When the trip was completed, the knob was pulled back to the starting point by hand.

The test board had only two layers of blocks, the under layer 4.4 cm. square, making the groove width at this level 25 cm. A single brass disc, 2 cm. in diameter, was attached solidly to the bottom of the stylus, which was in appearance identical with the practice maze stylus. It could be moved freely in any direction through all the grooves of the board, but could be lifted out only at the exit.

The mazes were placed side by side on tables of the same height. Each

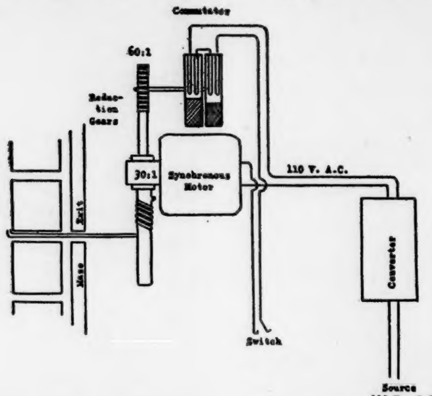


FIG. 2. DIAGRAM OF APPARATUS FOR PULLING THE STYLUS OF THE PRACTICE MAZE

was enclosed on three sides by beaver board 76 cm. high, painted light gray (figure 3). Flanges 12.5 cm. wide extending outward at a slight angle helped to prevent peripheral distraction of vision. Gray curtains concealed the mazes when desired.

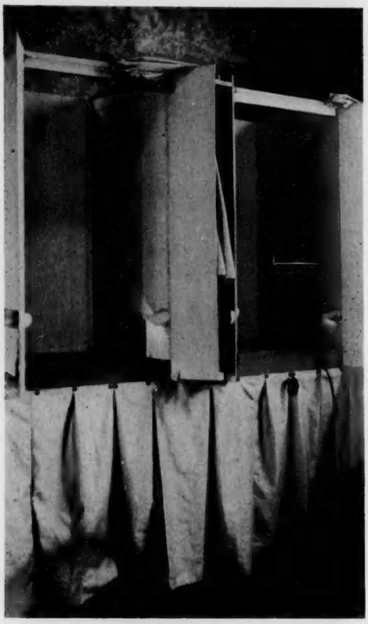


FIG. 3. MAZES READY FOR USE. PRACTICE MAZE TO THE RIGHT; TEST MAZE TO THE LEFT

A chin rest, adjustable to the height of the child, could be attached to the front of the practice maze.

Flash-light bulbs inserted in cardboard cylinders 4 cm. in diameter, with the reflector end cut slanting, were let into the beaver board at the front edges 7.5 cm. above the maze surface. These, on one circuit with 2 dry cells for the 4 lights, satisfactorily lighted the small light gray enclosure of the maze. Daylight was dimmed in the room by tan shades at the three small windows. The angle at which the lights were placed allowed the light to be reflected from the surface of the blocks without penetrating into the grooves.

At the correct exit from the test maze, an opening 15 cm. high and 12 cm. long was cut in the beaver board. Through this could be seen a small brass box, 84 by 40 mm., its top slightly above the level of the maze surface. This was wired so that when the child reached the exit by the correct route, the experimenter could touch a button which released the lid catch, allowing the lid to spring open and reveal an animal cracker within the box.

Wiring connections beneath the table were concealed by a curtain. The experimenter sat to the right of the practice maze where she manipulated the motor and the lights. During the tests she stood to the right of the child, where she could watch his performance. A drawing board was supported by the tops of the adjoining beaver board walls of the two enclosures. This held the record blanks and the button operating the cookie box.

The record blank was a reproduction of the maze with wider alleys, on which the experimenter traced the child's path in red pencil.

III. SERIES 1

A. Subjects and procedure

Fifteen children, ranging in age from thirty-five to fifty-seven months in

October, 1933, were the subjects for the first part of the experiment. They were all attending the Child Institute of the Johns Hopkins University.

The children were divided into three groups, matched for chronological age. The Intelligence Quotient for each child had been determined by the Stanford Revision of the Binet Scale, but in view of the doubtful reliability of intelligence ratings with such young children, the Intelligence Quotient was regarded less in the grouping than chronological age and observational estimates of the child's ability in his attack upon problems in his daily play life. The results seem to have confirmed the feasibility of this plan. Table 1 gives the ages and Intelligence Quotients at the beginning of the study.

The average superiority of Group III was considered no disadvantage, since the preliminary work with a similar group of children had already shown the method used with this group (mechanical guidance without vision) to be the hardest, and in view of the motor learning theories, it was planned to give this group any advantage that might accrue from superior intelligence. Preliminary work with 6 adults showed that this method presented some difficulty to them also. Only one learned after 3 demonstrations, four required 4 to 6 demonstrations, and one had not learned after 9 demonstrations.

The experimental work on the first training series continued from November 7, 1933, through February 1934. The Institute Christmas holiday includes the month of January, so that there was an unavoidable five weeks interim in the study. As will be seen later, it appeared to affect the learning very little.

TABLE 1

Age and Intelligence Quotient of subjects

GROUP I			GROUP II			GROUP III		
Child	Age	I.Q.	Child	Age	I.Q.	Child	Age	I.Q.
	months			*months*			*months*	
A	57	125	F	57	108	K	52	118
B	48	107	G	48	123	L	49	113
C	47	100	H	47	115	M	45	126
D	40	112	I	46	110	N	43	117
E	35	102	J	36	110	O	36	133
Average..........		109			113			121

Each child was given 6 practice runs and 2 tests at each period. A test followed each 3 demonstrations. If the child succeeded he was given a second test immediately, and a third if he succeeded upon that. The criterion of learning was 3 successive correct reproductions. A small amount of retracing, if his final decision was correct, was not counted against him in these tests, however. If he had not succeeded after ninety-nine to one hun-

dred and two training trials and thirty-three to thirty-four tests, the training was discontinued.

Group I—Visual and Manual Guidance

Children in Group I were allowed both to watch the knob and to grasp it lightly with the right hand as it traveled from the start to the exit. The supposition was that this combination of the two methods of tuition would prove the most effective since it seemed to duplicate the usual combination of visual and tactual-kinesthetic stimuli in the child's every-day learning of eye-hand coördinations.

Group II—Visual Guidance

Children in Group II were allowed only to watch the knob. A chin rest was adjusted to the child's height, and he was instructed to place his hands on the edge of the maze. Further attempts to control head movements seemed inadvisable with such young children. As a matter of fact, most of the children kept their heads quite still so far as the experimenter could observe.

Group III—Manual Guidance without Vision

Children in Group III were allowed only to grasp the knob with their right hands, and follow it around manually without seeing it. A gray curtain hung before the practice maze, and the arm was thrust through a slit. The maze lights were not turned on, so that the darkened interior was a further prevention of any accidental glimpses. This group, also, was allowed vision on the tests, since it seemed desirable to give all 3 groups the same chance to profit from any learning occurring during the tests. With all other conditions constant, any difference in results should be due to the difference in the training.

The experimental room was to the rear of the house, apart from the main play rooms. The furnishings were familiar to the child, and kept constant throughout the experiment. The noise of the converter and motor, the mechanics of the traveling knob, and the lights were all matters of interest at first. Some of the children soon disregarded them, others continued to manifest some curiosity. The ideal arrangement, of course, would have been to have these isolated. However, the children who continued to examine the set-up when allowed were the more alert, older children who were quickest to learn. Consequently, this interest did not appear to act as a distraction.

The child was brought from his play to the experimental room by the experimenter. On the first day he was first shown the test maze and instructed as follows:

"You see all these paths. Here is a little knob that will go anywhere I move it. Now watch and see what happens when I make it go a certain way."

The experimenter quickly moved the knob through the correct path to the exit, and opened the cookie box. The child was encouraged to look in and take the cookie. He was told that he might have it when he left. He was then shown the practice maze. Children of Groups I and II were told:

"Now I am going to show you on this board the way that little knob must go to make the box open. This little knob will only go the right way, and you may watch it. You must watch it carefully and learn the way it goes, so that you can make that little knob go the same way. I will let you watch it several times, and then you may try it on that board. When you get it right the box will open."

For Group I, the further instructions were:

"Put your fingers on the knob. Don't hold it tight."

For Group II, the addition was: "Put your chin here and your hands here."

Children of Group III, when taken to the practice maze, were told:

"I am going to let you put your fingers on the little knob here and feel the way that little knob must go to make the box open. This little knob will only go the right way, and you may feel it, but the game is not to see it. You must pay attention and learn the way it goes, so that you can make that little knob go the same way. I will let you feel it several times, and then you may try it on that board. When you get it right the box will open."

After each trip of the stylus, the curtain was dropped before the maze, the lights turned off, and the knob drawn back to the starting point. This short interval served as a brief rest period for the child.

After 3 guided runs, the child was led quickly to the test maze and told, "Show me the way it went." The experimenter drew a record of the child's performance in red pencil upon the record sheet. Time was taken with a stopwatch.

After the first period, the instructions were merely "Watch (or feel) carefully the way it goes, so that you can show me and make the cookie box open." Exhortations were confined to: "Watch (or feel) carefully;" "Watch (or feel) where the turns are;" "Try to remember the way it goes," and "You must learn the way the little knob goes if you want to make the cookie box open."

In the beginning each child was taken only twice a week. This proved unsatisfactory both from the point of view of time consumed in the series and for the child's optimum learning. From the first week in December on, each child was taken every day apart from the unavoidable interruptions due to illnesses and holidays.

B. Results: Series 1

From the record sheets, the following data were used as indications of learning: (1) the number of trials to learn; (2) the total distance covered by the child, measured in number of blocks passed, and the average number of blocks passed per test; (3) the total number of turns and the average number of turns per test; (4) the total number of right turns and the average number of right turns per test. The form of the learning curve, and the order of fixation of the turns were observed as of incidental interest. In addition, comments and illustrations of particular features of the learning in individual instances may furnish valuable insight into the process.

Number of Trials. Table 2, column 3, shows these data.

No child under forty-eight months of age learned the maze. Whether Child N would have learned it, had his practice continued, cannot, of course, be stated definitely, but in view of the fact that the three older children in his group did not learn it, it seems extremely doubtful.

Of the four children who learned, the two who were given only visual guidance learned with approximately half as many demonstrations as did those who were allowed to place their hands upon the knob as it traveled. These children were remarkably well matched. The average age and Intelligence Quotient of the two in Group I were identical with those of the two in

TABLE 2

Number of trials and tests, average number of blocks passed, average number of turns and average number of correct turns for each child in Series 1

Less than 99 practice trials indicates that the child successfully completed the learning

CHILD	AGE	NUMBER OF PRACTICE TRIALS	NUMBER OF TESTS	AVERAGE NUMBER OF BLOCKS PER TEST	AVERAGE NUMBER OF TURNS PER TEST	AVERAGE NUMBER OF RIGHT TURNS PER TEST
Group I. Visual and manual guidance						
	months					
A	57	69	29	16.2	16.5	5.2
B	48	78	29	17.6	20.3	4.5
C	47	102	34	10.5	19.4	1.5
D	40	102	35	18.8	15.0	2.2
E	35	102	34	8.8	17.9	0.6
Average..				14.4	17.8	2.8
Group II. Visual guidance only						
F	57	36	14	16.6	11.9	4.8
G	48	36	15	14.3	8.3	6.1
H	47	102	34	20.4	10.4	1.03
I	46	102	35	13.4	9.5	4.6
J	36	99	33	23.2	14.9	1.05
Average..				17.6	11.0	3.5
Group III. Manual guidance only						
K	52	102	34	16.5	12.6	2.9
L	49	102	34	20.3	14.7	2.9
M	45	99	33	19.4	11.6	2.2
N[1]	43	54	18	15.0	8.0	2.7
O	36	102	33	17.9	11.1	0.9
Average..				17.8	12.5	2.3

[1] Due to illness, Child N did not complete the learning series.

Group II. Child A and Child G, the two with the higher Intelligence Quotients, were rather negativistic and bored with the "game"; Child B and Child F were coöperative and interested. Thus, factors other than the difference in training method seem to cancel out. So far as any conclusions can be drawn from the performances of four children, with respect to the number of trials, visual demonstration alone was superior to manual guidance with vision.

None of the children in Group III learned the maze. The two oldest were fully the equal of the successful children in general ability, and were two of the most coöperative and interested children in the experiment. Apparently manual guidance without vision (though with vision allowed on the tests, so that they were not unfamiliar with the appearance of the maze) was an ineffective method of training in this experiment.

Since the ratio of tests to demonstrations was 1:3, except when the child was successful, extra tests indicate isolated successes. Table 2 indicates that Child A made four successful reproductions before he was successful three times in succession. The first of these occurred after 57 demonstrations. Child B also produced one additional true pattern, also after 57 demonstrations. Child G succeeded once after 30 demonstrations. Child D and Child I, although neither reached the criterion of three correct runs, each have one correct pattern to their credit. No child in Group III made even one correct reproduction of the path through which his hand was guided 100 times.

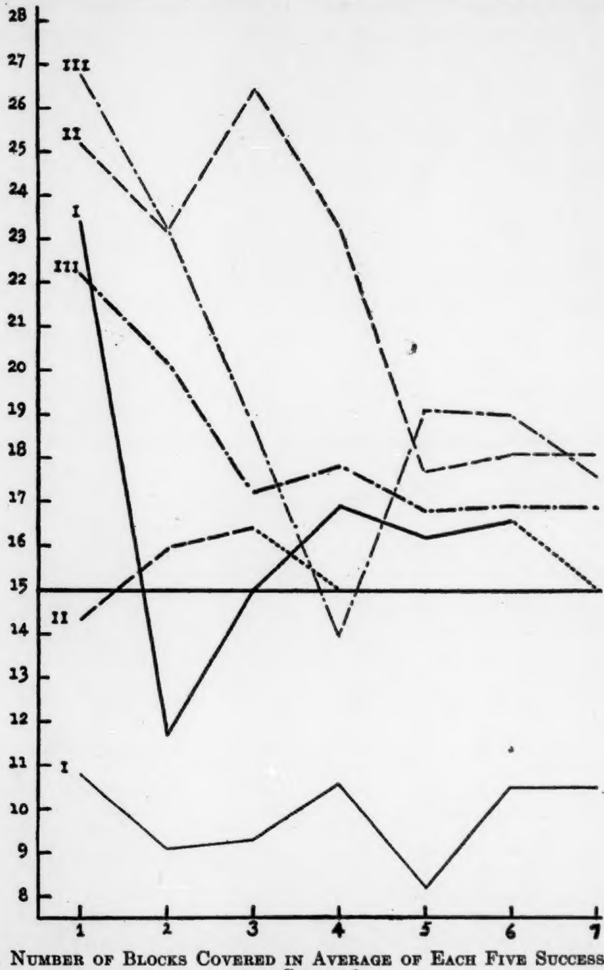
Distance covered. Table 2, column 5, shows the average distance per test covered by each child. Table 3 gives the averages in each successive five tests. The length of the true path was 15 blocks. Group I is nearest to the standard on the average, Group II next, and Group III last.

Inspection of these data reveal small differences between the records of the groups as wholes, or between the performances of those who did and did not learn. The individual differences are much higher than the average differences. Either distance covered is not a criterion of learning in this type of maze, or the number of subjects is not large enough to demonstrate definite trends. Graphic analysis, however, gives an indication of some differences which might or might not be verified in study of a larger group.

Graphs 1 and 2 are drawn from the average number of blocks per each five tests (table 3). Graph 1 shows group averages for the successful and unsuccessful children in Groups I and II compared with the average of their mates in Group III; graph 2 shows individual curves for Child D and Child I who each achieved one successful reproduction, and their mate in Group III, Child N, who did not complete the practice series.

These curves show that the *successful* children in Group I began with much excess distance, which they eliminated, while the *successful* children Group II began below the standard and worked up. With the *unsuccessful* children, the exact reverse is true. The children on the borderline who produced one successful test but not three conform to the tendency for the

successful children of their group (graph 2). The curves for Group III, all unsuccessful, show much excess distance with the exception of Child N (graph 2) whose average deviation in 18 tests is zero. Small average deviations, obviously, accompany good performance, and it is a matter of par-

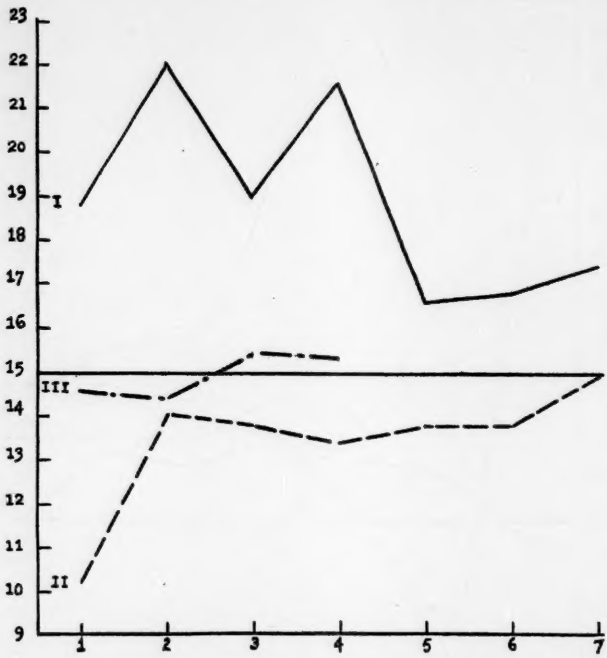


GRAPH 1. NUMBER OF BLOCKS COVERED IN AVERAGE OF EACH FIVE SUCCESSIVE TESTS IN SERIES 1

Curves for successful children in the seeing groups and their mates in Group III (heavy lines) compared with curves for unsuccessful children in the seeing groups and their mates in Group III (light lines). Group I: average A and B ——; average C and E ———; Group II: average F and G — —; average H and J — —; Group III: average K and L —.—; average M and O —.—

ticular regret that his trials could not be continued. It would be possible, on this maze, however, as his performance shows, to approximate the correct distance throughout the tests and yet never achieve the true pattern.

which useless movements are slowly eliminated. Yet with manual guidance alone, complete learning in this problem did not occur. The addition of vision was necessary to bring success. Moreover the short curve of



GRAPH 2. NUMBER OF BLOCKS COVERED IN AVERAGE OF EACH FIVE SUCCESSIVE TESTS IN SERIES 1

Children successful on one test, but not on three in succession, and their mate in Group III. Group I: Child D ———; Group II: Child I — —; Group III: Child N —.—

These differences in the direction of the deviation may be due only to individual variations in so small a group. On the other hand, they may reflect the effect of manual guidance. Where manual guidance was given exclusively or in part, such learning as occurred was characteristic of the motor type in

Group II is very much like the second half of the curve of Group I. This suggests the possibility, at least, that the children who had visual demonstration only (Group II) did their preliminary exploration visually, and that those who failed to do so in this group, failed to learn the maze.

TABLE 3

Distance and turns for each child as shown by the average for each five successive tests

Group I

Average number of blocks per five tests

A	20.8	11.8	14.4	18.4	15.4	17.0	
B	26.4	11.6	15.6	15.4	17.0	16.2	
C	13.4	6.8	7.8	10.6	10.2	12.8	15.5
D	18.8	22.0	19.0	21.6	16.6	16.8	17.4
E	8.2	11.4	10.8	10.6	6.2	8.2	5.5
Average...	17.5	12.7	13.5	15.3	13.1	14.2	12.8

Average number of turns per five tests

A	12.2	5.8	10.2	12.8	8.8	12.5	
B	14.0	11.2	10.0	9.2	11.6	9.6	
C	4.2	2.2	2.4	6.4	6.2	8.8	10.0
D	11.8	17.2	12.2	15.6	15.6	13.2	14.4
E	4.4	7.0	9.4	5.4	1.6	2.6	0.8
Average...	9.4	8.7	8.8	9.9	8.8	9.3	8.4

Group II

Average number of blocks per five tests

F	14.8	17.2	18.2				
G	13.8	14.6	14.6				
H	27.8	24.4	22.8	20.6	12.8	16.4	17.3
I	10.2	14.0	13.8	13.4	13.8	13.8	15.0
J	22.6	22.0	30.0	26.0	22.6	19.8	18.9
Average...	17.8	18.4	19.9	20.0	16.4	16.7	17.0

Average number of turns per five tests

F	9.8	13.6	10.0				
G	9.0	9.0	8.4				
H	10.0	14.8	12.0	12.4	5.8	7.4	8.4
I	7.8	9.8	10.2	9.2	9.6	9.8	9.8
J	9.0	13.0	15.2	16.4	16.6	13.0	12.3
Average...	9.1	12.0	13.2	12.7	10.7	10.1	10.2

Group III

Average number of blocks per five tests

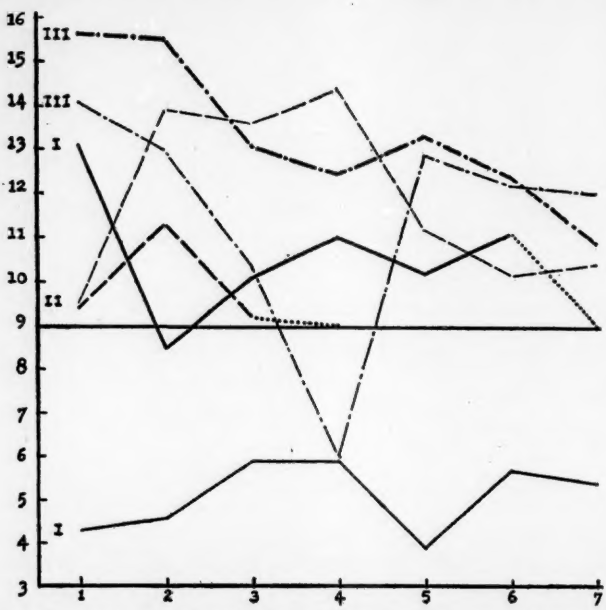
K	12.2	15.0	16.4	20.2	19.2	18.6	13.2
L	33.2	25.4	18.0	15.4	14.4	15.2	20.5
M	15.0	27.4	25.0	15.0	20.0	22.0	17.0
N	14.6	14.4	15.4	15.3			
O	28.6	19.2	12.6	13.0	18.2	16.0	18.3
Average...	20.7	20.3	17.5	15.8	17.9	17.9	17.3

Average number of turns per five tests

K	10.4	10.4	11.6	14.2	17.0	13.8	10.0
L	20.8	20.6	14.6	11.8	9.6	11.0	11.8
M	10.0	12.6	12.4	7.2	11.2	16.4	11.0
N	8.6	8.4	8.0	6.3			
O	18.2	13.4	8.4	5.8	14.6	9.0	13.0
Average...	11.8	13.0	14.4	11.2	13.6	13.6	10.1

Number of turns. Table 2, column 6, gives the data for the number of turns. The correct number of turns was 9. The average for Group I is closest to the standard, that for II next and III last. This is the same order that was shown for distance, though the differences were not quite so large. In either case, the number of subjects and the size of the difference is not large enough for statistical reliability. But if the direction of the differences is taken at face value, then it appears that the combination of visual and manual guidance in Group I was most effective in producing the correct amount of distance covered and the correct number of turns, *on the average.* None-the-less, the correct reproduction of the pattern occurred much sooner by the second method.

The curves drawn from the averages of turns for 5 successive tests in table 3 show the same general characteristics as those for distance. Comparison of the two sets helps to summarize the observations possible from these measures of the learning. In the following, 15 blocks and 9 turns are taken as the "standards" in distance



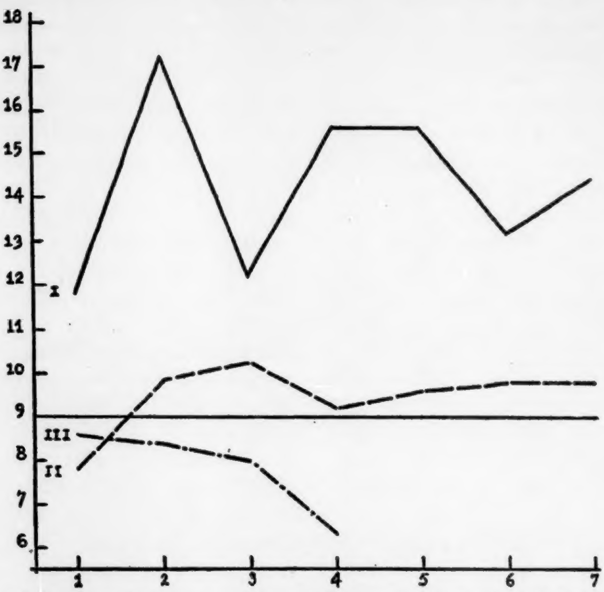
GRAPH 3. NUMBER OF TURNS IN AVERAGE OF EACH FIVE SUCCESSIVE TESTS IN SERIES 1

Curves for successful children in the seeing groups and their mates in Group III (heavy lines) compared with curves for unsuccessful children in the seeing groups and their mates in Group III (light lines). Group I: average A and B ———; average C and E ———; Group II: average F and G — —; average H and J — —; Group III: average K and L —.—; average M and O —.—

and turns, and deviations above or below these are called simply plus or minus variations.

In Group I the *successful* children vary in distances from 8.4 to −3.3 blocks, or through 11.7 blocks; the *unsuccessful* from −4.2 to −6.8 blocks, or through only 2.6 blocks. In turns, as in distance. *Failure* apparently resulted from lack of initial excess activity, or random exploration.

In Group II the *successful* children varied from −.7 to +1.4 blocks, or through 2.1 blocks; the *unsuccessful* from +11.4 to +2.7, or through 8.7 blocks. In turns the *successful* children varied from +2.3 turns to 0; the *unsuccessful* from +5.4 to +.5, or through 4.9 turns. *Success from this method of guidance*, then, appears to require almost no excess activity in distance and a similar close adherence to the standard in turns, with about the same amount of variation in each. *Failure* in this case resulted from ex-



GRAPH 4. NUMBER OF TURNS COVERED IN AVERAGE OF EACH FIVE SUCCESSIVE TESTS IN SERIES 1

Children successful on one test, but not on three in succession, and their mate in Group III. Group I: Child D ———; Group II: Child I — —; Group III: Child N —.—

the *successful* children varied from +4.1 to −.5 turns, or through 4.6 turns, while the *unsuccessful* varied from −3.1 to −5.1, or through 2.0 turns. Requirements for success by this method of guidance, then, appear to be: (1) a considerable amount of excess distance to be eliminated; (2) some excess in turns, but not so much

cess activity both in distance and in turns.

In Group III, manual guidance only, the deviation from the standard is strongly positive in all cases except for the one point below the standard in graph 3.

It is tempting to speculate here. The manual guidance without vision resulted in excess motor activity, rather undirected, in which a slow approach to the correct distance and number of turns occurred, but the pattern was not learned. As a previous author observed, kinesthesis may indicate that a turn is to be made, but visual or tactual cues are needed to indicate where. Members of Group I perhaps reacted to the manual guidance first, and their records show the motor pattern in the beginning. Later, when unsuccessful, they changed to a visually guided reaction. Those who were allowed only to watch the knob possibly gave their whole attention from the beginning to the visual guidance of their hands in the test situation.

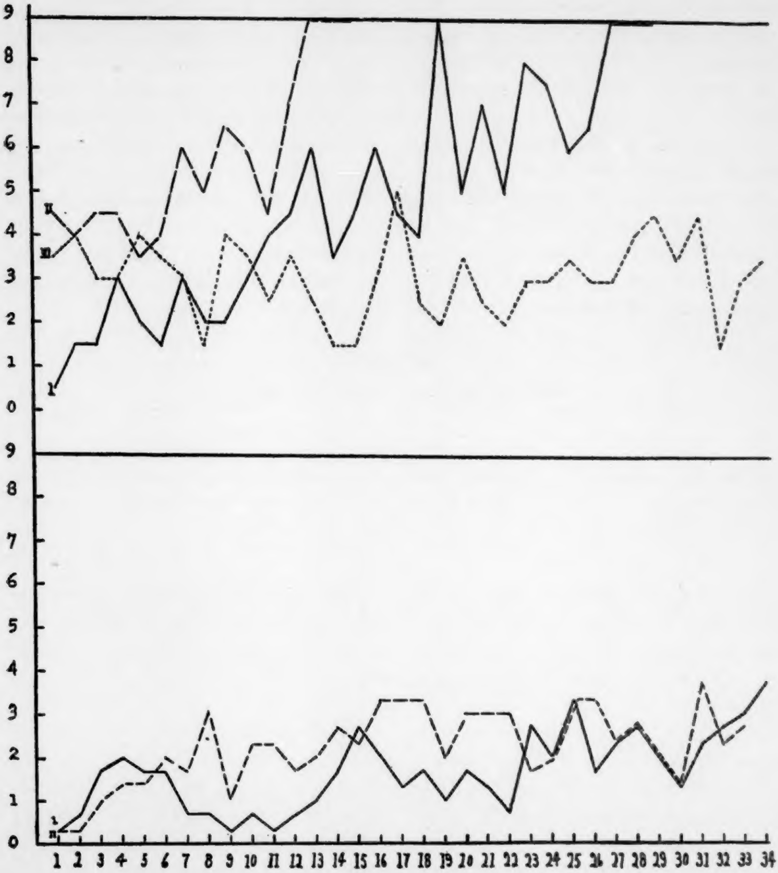
Whether verbalization entered into the learning or not was not ascertained in this study.

The individual curves, (graphs 2 and 4) illustrate partial learning in Child D and Child I, and incompleted series for Child N. Child D did not improve on the average in number of turns, but did improve in distance. Child N, though he judged the distance very well, was slowly departing from the standard in number of turns.

Number of right turns. The type of maze used offered scoring difficulties. Whereas in the ordinary maze, each excursion into a cul-de-sac must be followed by a return to the correct path at the same point where it was left if the exit is to be reached, in this maze the subject might leave the true path at any point and join it again later, or not at all, after any amount of random exploration. Where the record contained more or less than the requisite 9 turns, even though a few of the turns were at the correct point, it was not possible to be sure which part of the pattern the child had intended that particular section to represent. The method finally adopted to overcome the difficulty was simple. Turns were counted as correct if they occurred at the correct point in consecutive order counting *either* from the *beginning* or the *end* of the pattern. Thus, if a line in the right direction traveled around turn 6, it was counted as correct if, in the child's pattern, it was the sixth turn from the beginning or the fourth turn from the end. According to this scheme, table 2, column 7 shows the results.

This record gives a more accurate reflection of the child's performance than does the distance or the total number of turns. Here the group averages are in agreement with the fact that children of Group II learned in fewer trials than those of Group I. Child N, whose total distance and turn scores were so much nearer the standard than those of others of his group, none-the-less had no more right turns than the majority of the others. Child I, it is true, has as high a score as some who were successful, but his record shows that he repeated a pattern a great many times in which a number of the turns were correct without correcting the few mistakes.

The most striking fact throughout this analysis is that no differences can be shown which are in any way large



GRAPH 5. LEARNING CURVES CONSTRUCTED FROM THE NUMBER OF CORRECT TURNS PER TEST

A. Group averages for successful children in the seeing groups and their mates in Group III. B. Group averages for unsuccessful children in the seeing groups.

enough to account for the fact that Children F and G learned the pattern in half as many trials as Children A and B. The averages of distance covered, of turns per test, and of right turns per test are different from those of the children who did not learn the maze, but not strikingly different from each other. Only in the graphic repre-

sentation of the *direction of deviation*, do we find a clue which might point to a solution of the problem, namely: that the 2 children who learned with the aid of motor guidance tended toward excess motor activity in the beginning, while those who only watched the knob avoided this preliminary stage.

The form of the learning curve. Graph 5 shows the learning curves, constructed from averages of the number of right turns per test of Children A and B, F and G, K and L, C, D and E, and H, I and J. Group differences are marked. The successful children similar to this although upon a lower level.

The curves for the unsuccessful children in Groups I and II are consistent with those shown by the successful children and display the same differences at a lower level. Although in this case they begin at the same point, the curve for Group II never sinks to the starting level again after the second test, while Group I falls to the starting point again on the ninth and eleventh tests. The rise of the curve in its first half is steeper in II than I and the high level is maintained more consistently in the former.

TABLE 4

Relative difficulty of turns in the maze

	TURN NUMBER								
	1	2	3	4	5	6	7	8	9
Times correct	352	125	39	36	35	104	135	146	215
Rank in difficulty	(1)	(5)	(7)	(8)	(9)	(6)	(4)	(3)	(2)

in Group II started at a higher level than those of Group I. On the first trial they attained a score not reached by the two children of Group I until the twelfth test. Again, the saving by this method is shown to have been in the first half of the learning curve.

The curve for the average of Children E and L in Group III ends at exactly the same point as it began. It even has a slight downward slope for the first half of its course, although it began nearly as high as the curve for Group II. In fact it appears to represent admirably the efforts of a person groping in the dark. The curve for the remaining three children in Group III has not been included since it is

Order of fixation of turns. From the total number of times each turn was correctly negotiated, the order of difficulty of the turns in the maze was calculated. This is shown in table 4.

This is consistent with other studies which have shown the first and last items of a series to be the first learned, while the middle items are the hardest. In this case the third, fourth and fifth turns proved about nine times as hard as the first turn and about six times as hard as the last.

Comments upon individual performances. There were several varieties of failure, which no mathematical treatment of the records can bring out. They reflect both the results of the

method of guidance and the personal reaction of the child. Some of these are the following:

1. Aimless wandering. Child M's record was typical. He started out well, but apparently was lost after the third turn and retraced up and down the grooves until stopped at the end of 45 seconds by the experimenter.

2. Quick, impulsive action with (a) no apparent attempt to reproduce the pattern, or (b) a very much abbreviated pattern.

3. An attempt to produce a pattern, but with no similarity to the true pattern.

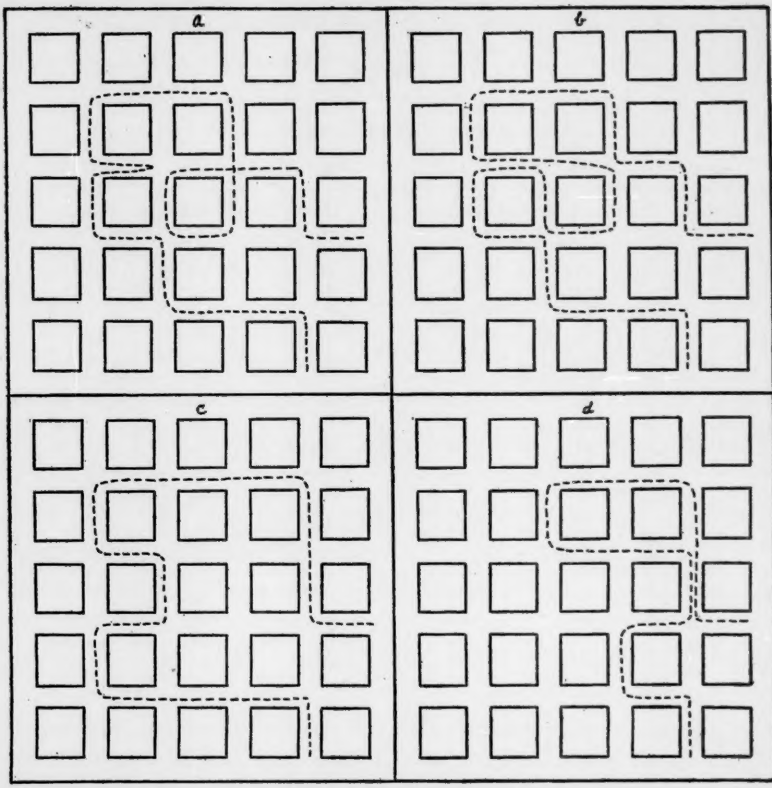


FIG. 4. INDIVIDUAL RECORDS

a. Child K, age 52 months. Test 1 after 81 guided trials, time 19 seconds. *b.* Child K age 52 months. Test 1, after 87 guided trials. Time not taken. *c.* Child L, age 49 months. Test 1 after 75 guided trials, time 18 seconds. *d.* Child L, Test 1 after 96 guided trials, time 9 seconds.

4. The best records of the oldest children in Group III are extremely interesting. They show varying approximations to the pattern in the

effort to reproduce a series of unseen hand and arm movements. Child K (see figure 4) evidently felt he should go around the middle block, but could not find the way to start. Child L has the number of turns correct in both records, also the direction of the turns and some of the proportions. Such records as these often occurred just before learning among the older children in Groups I and II. Child L never eliminated these errors.

IV. SERIES 2

A. Subjects and procedure

At the completion of the first series of 100 demonstrations for each child, the following questions arose:

1. Since the problem, as it stood, was too hard for the younger children of the two seeing groups, would it be possible for them to learn it if it were simplified by shortening the maze?

2. Could any of the children of the non-visual group learn the path if it were simplified by shortening?

3. Was the introduction of vision on the tests for the non-visual group really a confusing rather than facilitating procedure?

4. Could children who had once learned the maze with vision relearn it without vision?

To settle these questions, a new series of 100 demonstrations each was given to six groups, under the conditions indicated in table 5. The age

TABLE 5

Age and intelligence quotients of children for the second series of demonstrations

1. *Reduced maze,* trials and tests as in Series 1

CHILD	AGE	I.Q.	CHILD	AGE	I.Q.
Group I. Visual and manual guidance			Group II. Visual guidance only		
	months			*months*	
C	51	100	H	51	115
D	44	112	I	50	110
E	39	102	J	40	110
Group III. Manual guidance only			Group IV. No vision on tests or trials		
K	56	118	R	52	96
L	53	113	S	50	123
M	49	126	T	43	111
O	40	133			
2. *Original maze,* no vision on tests or trials					
Group Va. No previous trials			Group Vb. Previous success with vision		
P	58	98	F	61	108
Q	49	117	U	54	140
			B	52	107
			G	52	123

is given as of March 1, 1934, when this series was begun.

The original maze was shortened, as shown in figure 5, by covering the outer row of blocks on two sides of the maze with an L-shaped sheet tin lid, painted the same color as the maze. Four turns, the first two and the last two, were thus cut off from the original pattern, making the length of the true path 9 blocks, and the number of turns, 5. Since in the original, the end of

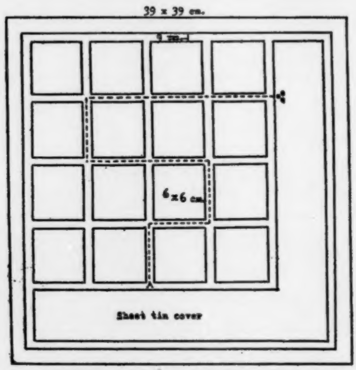


FIG. 5. SURFACE VIEW OF REDUCED MAZE
The dotted line indicates the path traveled by the knob on the practice maze.

the path was clearly marked by the exit from the maze, the finish in this reduced pattern was marked by the three small gold stickers shown in this diagram.

Groups IV and Va were instructed just as Group III had been previously, but when they were taken to the test board the curtain was not removed.

Group Vb was told:

"You remember how we played this game the last time. You learned the way the little knob went, and you made the cookie box open. The little knob still goes the same way it did before. I want to see if you can make the cookie box open when you cannot see the way the knob goes."

Groups I, II, and III were told: "You see, I have covered up some of the blocks in the game. The little knob does not make so many turns, and it may be easier for you to remember the way it goes.

"We will play this game just the way we did before. When you make the little knob go the right way the box will open. I will show you the right way over here, and you will show me there."

The rest of the procedure was precisely the same as in the previous series.

B. Results: Series 2

Number of trials. The results of this series are presented according to the same scheme as that for the previous series. Table 6 shows the number of trials for each child.

Table 6 answers the questions stated. No child who was not permitted vision on the tests or trials (Groups IV, Va, and Vb) learned the maze, not even children in Group Vb, who had previously learned it with vision. Not one of these children, in fact, produced even one correct pattern.

Three of the younger children, who had not learned the full maze in the seeing groups, learned the reduced maze. Child D, and Child I, both of whom produced one correct test on the full maze but were unable to reach the criterion of 3 perfect tests, learned this easier pattern after very few demonstrations. Child I, having visual guidance only, learned after 6 trials, just

half as many as were needed by Child D, who received visual and manual guidance. This is exactly the same ratio as obtained between the number of trials required for successful learning by the older children trained by these methods in Series 1.

TABLE 6

Number of trials and tests for each child

Less than 99 trials indicates that the child successfully completed the learning

Reduced maze

CHILD	AGE	TRIALS	TESTS	CHILD	AGE	TRIALS	TESTS
Group I. Visual and manual guidance				Group II. Visual guidance only			
	months				*months*		
C	51	102	34	H	51	102	34
D	44	12	7	I	50	6	4
E	39	78	28	J	40	99	33
Group III. Manual guidance only				Group IV. No vision on tests or trials			
K	56	15	7	R	52	102	34
L	53	102	34	S	50	102	34
M	49	102	34	T	43	102	34
O	40	102	34				
Original maze. No vision on tests or trials							
Group Va. No previous trials				Group Vb. Previous success with vision			
P	58	99	33	F	61	99	33
Q	49	102	34	U	54	99	33
				B	52	99	33
				G	52	102	34

Child E (Group I) learned the maze in 78 trials, while Child J (his partner in Group II) did not complete the learning. This is the only instance in which the combined manual and visual guidance appeared superior to the visual only. This might be due to individual variations. On the other hand, we may have here an indication that manual guidance actually is more efficacious at about three years and under. However, a special circumstance should be related in this case. This child never appeared to comprehend the instructions very clearly. After the thirteenth test, when the experimenter had brought him back to the practice board for the fortieth trial, she said, "I believe you really know the way that little knob goes. It starts here, and where does it go next?" To her amazement, he indicated the correct path with his finger, and could do it as many times as asked. He was then taken back to the test board and told: "Now do just what you did over there. It starts here, and where does

it go next?" He was unable to produce the correct pattern on the test board, although he approximated it. Thereafter the trials and tests continued as before, the experimenter saying for each test: "Where does it go next?" The child did not succeed in the usual manner on the test board until after twice as many trials as this demonstration on the practice board required, and it is probable that he could have shown the way earlier on the practice board if he had been asked. Possibly he had observed small cues there which pointed out the path to him without his actually having learned it. No other child was found who exhibited this ability on the practice board, or to whom the change in the wording of instructions seemed to make any difference, although others of the younger group were tried after this discovery.

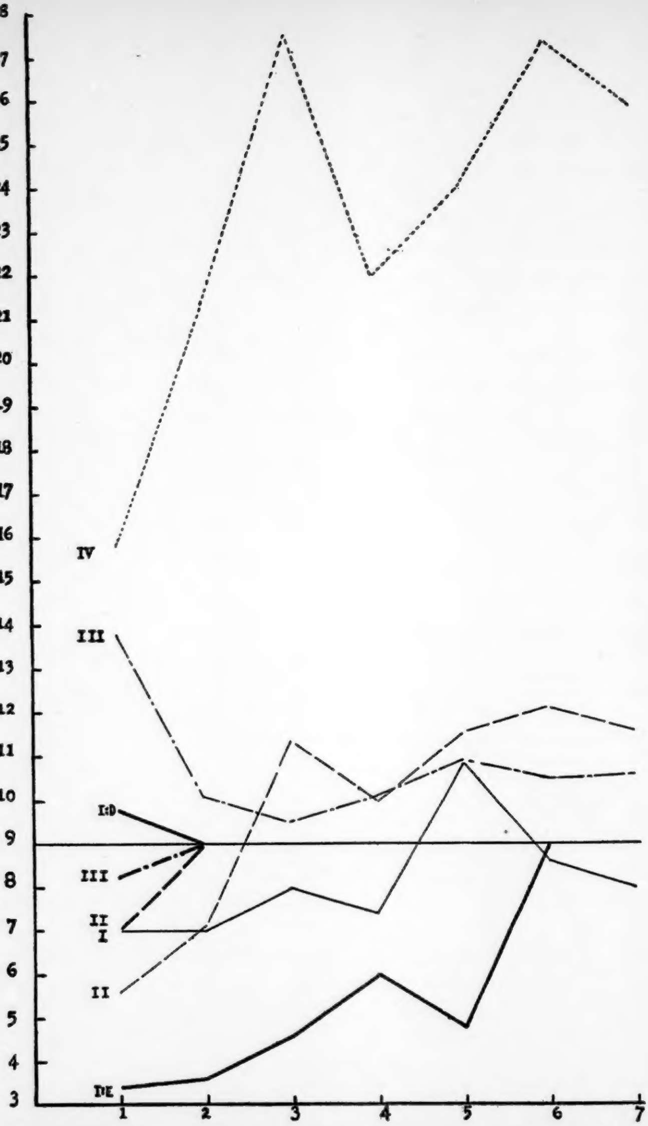
Child K (Group III), learned the pattern to the point of three correct reproductions after fifteen trials on the reduced maze with manual guidance only. Child K was the oldest child in Group III. Kinesthesis, far from being the best guide at the youngest ages, was only beginning to be an adequate guide for a child almost five years old, and this when vision was allowed in the test situation.

Distance covered. The total distance covered by each child and his average distance per test and per five tests were calculated for this series as in the previous series. The complete table has been omitted as unnecessarily cumbersome. The length of the true path for the reduced maze was nine blocks.

The same trends observed in the first series were even more evident here. Group averages of the number of blocks covered per test compared with the standard show the following deviations: On the reduced maze, Group IV +14.2 blocks, Group III +1.3 blocks, Group II +.6 blocks, Group I −1.4 blocks; on the full maze, Group Va +12.2 blocks, Group Vb +1.2 blocks. The ranking of the groups by average deviation (in which the positive and negative deviations are disregarded) is the same as that above except that Groups I and II change places, Group I having a higher average deviation than Group II.

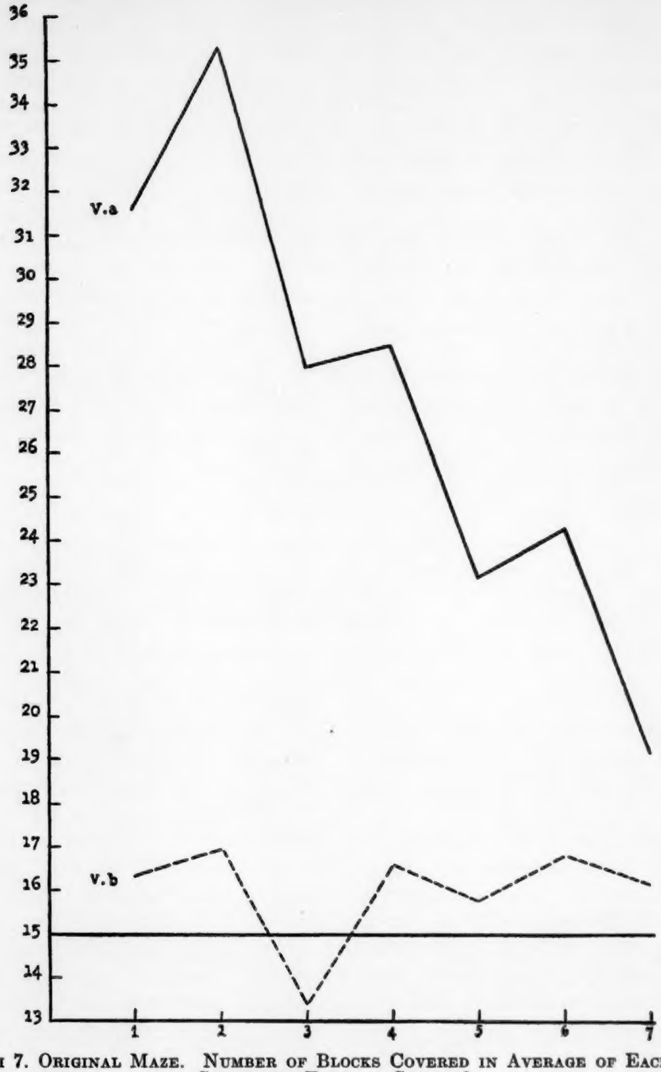
These results emphasize once more that vision tends to reduce random motor exploration. The introduction of vision in the test situation in Group III of Series 1 was an aid, not a confusing factor. Groups IV and Va, composed of children who had not previously been trained on the maze and who were allowed vision on neither the practice nor the tests, show the largest amount of excess distance covered. Next in order is Group III, children who had never had visual guidance. Group IVb ranks next, although there is only 0.1 block difference between this and Group III. These children had previously learned the maze with vision, but were allowed no vision either on practice or on tests in this series. The effects of the previous visual training about equalled the effects of vision on the tests.

It might be expected that Group I should rank next in order as showing the effects of the manual guidance, and Group II last. In Series 1, as we noted there, the same reversal occurred, due to the wider negative deviation of



Graph 6. Reduced Maze. Number of Blocks Covered in Average of Each Five Successive Tests in Series 2

Curves for successful children (heavy lines) compared with curves for unsuccessful children (light lines). Group II. I is not an average of five tests, but the actual tests, as there was only one previous to success. Group I: D and E ———; C ————; Group II: I — —; average H and J — —; Group III: K —.—; average L, M, O —.—; Group IV: average R, S, T ....



GRAPH 7. ORIGINAL MAZE. NUMBER OF BLOCKS COVERED IN AVERAGE OF EACH FIVE SUCCESSIVE TESTS IN SERIES 2
Group Va: average P, Q ——; Group Vb: average F, U, B, G — —

the unsuccessful children overbalancing the positive deviation of the successful in Group I. Here the same explanation would hold were it not for the case of Child E, already described as unusual. The effect of one record in so small a number of cases unfortunately calls all the group results into question.

Graphs 6 and 7 drawn from the averages of successive five tests illustrate the above observations and are in most respects consistent with the findings from the previous series. With the exception of Child E, the younger children who were successful on the reduced maze were those who had been on the verge of learning the larger maze and a very few trials on this easier problem sufficed to bring them to the criterion of three perfect tests. Child E is an exception to the previous progress of successful children in Group I. Child K, the only child in any series successful by the manual guidance alone, is surprising in that his short curve is like that of Group II instead of Group I.

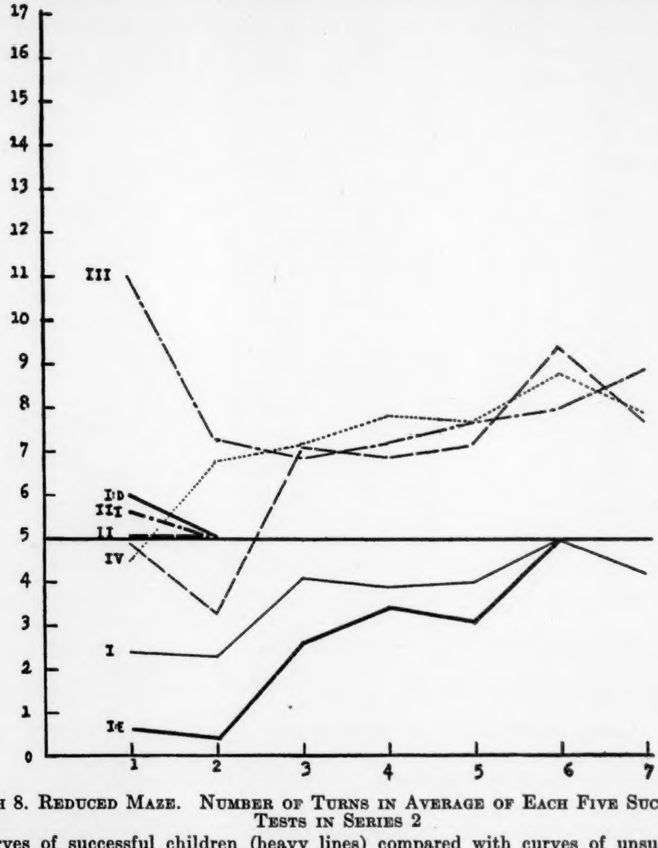
Number of turns. The number of turns for each child was also counted and treated as in Series 1. It was noted that while the amount of deviation from the standard for Groups I, II, III and IVa was very nearly the same for distance and for turns, with Groups IV and Va the deviation from the standard in distance was about 7 and 2 times, respectively, the deviation from the standard in number of turns. The absence of visual guidance on both trials and tests encouraged random retracing and a maximum of distance covered with a minimum of turns.

The form of the learning curve. The number of correct turns for each child was determined by the method described in Series 1. The group averages for the number of right turns per test is as follows: Group I, 1.8; Group II, 2.1; Group III, 1.5; Group IV, 0.2; Group Va, 0.7; Group Vb, 2.5. (See graphs 8 and 9.) The surprising feature here is that Group Vb has the highest average, although not one child produced an entirely correct test. The effects of the previous success with vision were strong enough to bring these children to the first rank by this criteria, whereas children learning by the same method who had had no previous practice series (Groups IV and Va) ranked last. Children who had had as much previous practice in Series I without vision on the practice but with vision on the tests ranked fourth in order. As in the previous series, Group II was the best of the three original groups.

The unsuccessful children in Groups I, II and III differ from those of the previous series in that Groups I and II show no upward trend, Group III does after trial 26. It is probable that the children who did not learn with vision at this level never comprehended the problem, and that the slight upward trend of the curves of unsuccessful children in Series 1 was due to the presence in the group of the children who were successful on the reduced maze of Series 2. In Group III the older children began to succeed a little better with the easier problem.

In summary, the results of Series 2 show that the reduction in size of the maze made the problem of about the

same difficulty for the younger children that the original maze was for the older ones. Learning without visual guidance was more difficult for the sion on the tests or practice was by far the most difficult method of all. In most respects the indications from Series 1 were confirmed by Series 2,



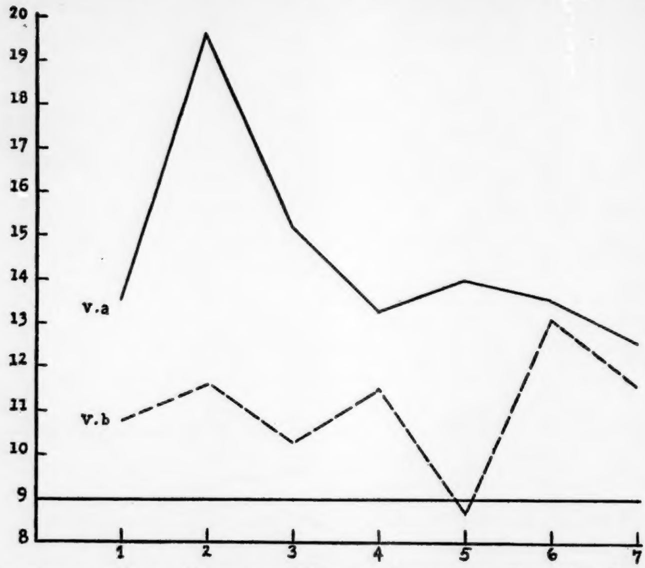
GRAPH 8. REDUCED MAZE. NUMBER OF TURNS IN AVERAGE OF EACH FIVE SUCCESSIVE TESTS IN SERIES 2

Curves of successful children (heavy lines) compared with curves of unsuccessful children (light lines). Group II, I, is not an average of five tests but the actual tests, as there was only one previous to success. Group I: D and E ——; C ———; Group II: I — —; average H and J — —; Group III: K —.—; average L, M, O —.—; Group IV: average R, S, T ....

older children of Group III on the short maze than the original maze had been for the younger children of the seeing groups. Learning without vi- where the same phenomena appeared upon a lower level. The less visual and the more manual the training and testing, the more random motor ac-

tivity occurred, and the less was the likelihood of success. Such a decided contrast probably would not be found with a different type of maze in which random activity itself would be likely to produce eventual success.

Comments upon individual performance. Some varieties of failure be-ings, and particularly in connection with Rice's recent study of this feature, the record of Child J (figure 7) is interesting as an example of a pattern which recurred many times, among the unsuccessful children. This reversal of the pattern in turning left instead of right at the first turn also



GRAPH 9. ORIGINAL MAZE. NUMBER OF TURNS IN AVERAGE OF EACH FIVE SUCCESSIVE TESTS IN SERIES 2

Group Va: average P, Q ——; Group Vb: average F, U, B, G — —

came more obvious in this second series than they had been in the first. Aimless wandering was carried to the extreme in the non-visual groups, with emphasis upon retracing. Child P's record on the long maze, shown in figure 6, is an example of this tendency.

In connection with observations by the early child psychologists upon the lack of orientation in children's draw-occurred in the long maze at this point, where it was the third turn instead of the first. Once this had appeared, it seemed especially difficult to eradicate. Thirteen of Child J's tests, 14 of Child L's, 15 of Child M's and 8 of Child O's records were of this pattern. All the children of Group III, in fact, seemed unable to correct this error. The kinesthetic impulses evidently in-

dicated a turn, but not the direction of the turn. Child M, after 90 trials and his thirtieth test, remarked "Well, that's wrong, but that's the way it went, though."

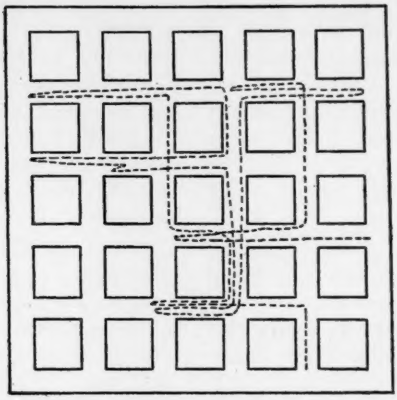


FIG. 6. INDIVIDUAL RECORD OF CHILD P, 58 MONTHS OLD
Test 1 after 18 guided trials, time 39 seconds

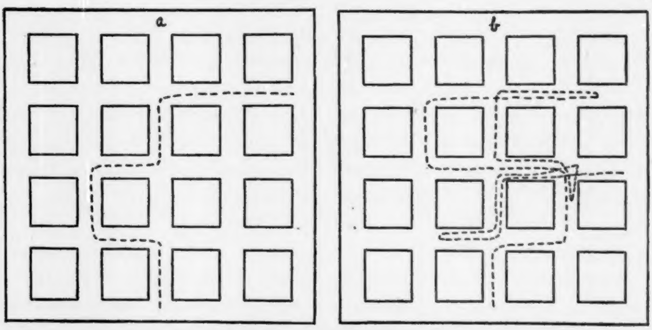


FIG. 7. INDIVIDUAL RECORDS
a. Child J, 40 months old. Test 1 after 87 guided trials, time 7 seconds. *b*. Child O, 40 months old. Test 1 after 81 guided trials, time 20 seconds.

Child O was the only one who seemed confused by the change from the large to the smaller maze. His record, shown in figure 7, is peculiar in that he actually reproduced the pattern in his first five turns several times, but he never learned to stop after this performance. Instead he continued as shown in his record. He appeared to be trying to get to the exit from the long maze, where the cookie box was.

CONCLUSIONS

The goal of this study was to set up a problem in which children must learn a motor task by one of three methods: (1) through predominantly visual cues, (2) through predominantly manual cues, or (3) through a combination of the two. If there is a tendency for children to depend primarily upon kinesthetic cues other than visual, it was hoped this experiment would demonstrate that fact.

There were 21 children in the experimental group. This small number of cases prevents the statement of definite conclusions. Nevertheless, the results appear to present very definite indications in some directions, while other more tentative findings open interesting avenues for speculation.

There is little doubt that the method of training in which manual guidance without vision was employed was much less effective in producing successful learning than were the visual methods. Preliminary trials with 6 adults had shown that manual guidance without vision presented a real problem to them in reproduction, but the assumption that the adult has shifted to visual dominance while the young child relies mainly upon tactual-kinesthetic cues, would lead us to expect the opposite results with children. This was not the case.

The facts upon which the relative difficulty of the non-visual method is asserted are the following: (a) No child in the non-visual group (no vision in the guided practice trials, vision on the tests) learned the correct pattern in the long maze, whereas four older children in the visual groups (vision on both practice trials and tests) did learn it. (b) When the maze pattern was shortened, only the oldest child in the non-visual group learned the pattern, while 3 of the younger children in the visual groups learned this easier task. (c) Vision on the tests only was of considerable benefit, as shown when the non-visual group of Series 1 was compared, in Series 2, with a group allowed no vision either in practice or in tests. By the criteria of distance covered, number of turns, and number of correct turns, the first group came much nearer to the standard than the second. It is probable that the vision in the tests was in some ways comparable to the insertion of visual trials. (d) Children who had once learned the maze with the aid of vision were unable to relearn it without vision on practice or tests, although the effects of their previous visual training were obvious when distance and turns were compared with the other non-visual groups.

Differences between the two visual groups (visual guidance only, and visual and manual combined) are not so definite, but tend to show that visual guidance alone is superior to the combination. This conclusion rests mainly upon the comparative number of trials required by the successful children in both groups. Success by the visual guidance was attained in half as many trials as by the combination. Since this relationship rests upon the records of only 6 children, the individual variation may have biased the results. The youngest child in the visual-manual group was successful on the easier problem, while the youngest child in the visual group was not.

The manual guidance alone resulted in wide random exploration on the tests. This was still more marked when vision was not allowed on the tests. Visual guidance alone resulted in quite limited initial exploration among the successful learners. Possibly here the preliminary exploration had been visual. Visual guidance on the trials probably requires less passivity on the part of the child than the manual, since the eyes may explore the maze and return to the moving knob during guidance, while this is not possible in manual "putting through." This does not explain, however, why the combined method was less effective than the visual alone. Possibly, the combined method involved a division of the attention between the two types of cues, and the manual cues acted as a stimulus to excessive activity and therefore as a distraction from the problem itself, rather than as an aid.

It is possible that visual guidance was at a premium in the set-up of this problem as was the case in some experiments of Richardson's (30) and in Walton's (34) study with rats. In that case, the conclusion is simply that children, as young as three years, can learn a motor task of a certain degree of difficulty when it is presented to them visually.

Carr (4 and 5), on the basis of his study where visual and manual guidance were combined, suggested the alternatives that the effect of vision might be (1) a visual memory of the maze; (2) prevention of tactual-kinesthetic errors in the learning process. This study, in which visual guidance without manual proved more effective than a combination, throws weight toward the visual memory hypothesis.

Carr (4) was also of the opinion that individuals develop a visual idea of a maze pattern through non-visual guidance—an opinion opposed by the work of Brown, Husband, and Cutsforth. Our results indicate that if any visual idea was developed by these children through the manual guidance alone, it was an entirely erroneous one.

Other studies of method (35) showed that of the three methods of learning, verbal, visual imagery, and kinesthesis, the verbal was most effective, visual next, and the kinesthetic least. It was generally assumed that the learning of young children was mainly kinesthetic. Results of this study indicate that by three-and-a-half to four years at least, vision plays an extremely important rôle. It seems likely that any shift in receptor dominance from the kinesthetic to the visual modes has occurred by this age, and not as late as puberty—as some have advocated. The later shift is more likely toward increased dependence upon verbalization in ideational activity.

Whether verbalization played a part in the learning could not be ascertained. Some of the children could count as high as 10, but their actual concepts of number were not above four or five objects. Even granting their ability to count the turns, it is doubtful if this method occurred to them. Pyles' (25) study showed that naming of objects was an aid to learning but there the learning consisted in identifying an object of geometrical design, not repeating a movement. Johnson (17) found that children four

to five years of age remembered two to three movements in the Knox Cube test after one demonstration. Repeated demonstration, in this study, resulted in memory of the successive movements in a longer series.

These results show that the lack of improvement in the ability of young children to reproduce a pattern, found by Hicks and Ralph (12) in a study of practice in tracing the Porteus Maze, and by Rice (29) after eye and hand training on the diamond, was probably due to the small amount of practice given in these studies. In this study, children three years of age improved measurably in ability to reproduce a complicated figure after 100 visually guided trials, even where learning was not complete. Rice's finding that success in reproduction was correlated with perceptual level rather than motor ability is confirmed and further defined by this study. Her work implies that perceptual level is dependent upon age and cannot be improved by training. This study indicates that it can be improved if the training is continued long enough.

With reference to the problem as stated in the beginning (p. 315) it has been demonstrated that stimuli initiated by the visual processes alone can produce appropriate motor responses in children as young as three years. Whether children younger than this must rely on kinesthetic stimuli from the responding organ itself for skillful motor activity is yet to be shown.

Further research on this problem should be directed, first, toward verifying the findings here presented with a larger group of children.

The disadvantage of this particular apparatus is in the difficulty in recording errors. A set-up which permits automatic recording of the child's performance should be devised.

This experiment has shown that visual cues were indispensable for learning in this particular situation. Other studies have indicated that it is less necessary in other situations. Analysis of the factors which are responsible for this difference should be attempted. There are indications in this study that cues from the manual guidance may result in elimination of excess distance after long training, and the correct number of turns may be achieved, but all this cannot be integrated into a particular pattern without visual aid.

Determination of receptor dominance should be pushed even further back into infancy by devising situations in which infant learning may be analyzed. Older children should also be studied with a view to establishing the hypothesis indicated by this study, namely, that the ability to use kinesthetic cues as the sole guidance in learning a series of coördinated movements that form a definite spatial pattern probably develops with age, instead of retrogressing. Further study should be made as to the part verbalization plays in the above process.

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Age Changes in the Physical Resemblance of Siblings[1]

CARROLL E. PALMER

NUMEROUS investigators, notably Galton (6), Pearson (11, 12), Pearson and Lee (13), Thorndike (14), Fisher (5), and many others, have studied various aspects of problems connected with the resemblances of offspring of the same parents. So far as can be ascertained, it is assumed in the studies thus far made that fraternal resemblance is static during the whole of life or, if such an assumption is not made, that it is sufficient to determine an average degree of resemblance which may be considered representative of all ages. From certain points of view, especially those relating to problems of inheritance, it may be immaterial whether or not fraternal resemblance remains precisely constant during the entire life span. In problems dealing with human growth, however, it would appear that a study of the change with age in the resemblance of children of the same parents might be of value in the analysis of certain sources of variation observed in growth processes.

An example of the kind of problem to which, inferentially at least, a study of the growth resemblances of siblings might be expected to contribute, arises in connection with the analysis of the marked increase in the variability of physical characters which occur in both boys and girls near the time of sexual maturation. One of the principal characteristics of this part of the growth cycle, as is well known, is a sudden acceleration, followed by a deceleration, in growth processes. Concomitantly with this acceleration and deceleration there occurs a great increase, followed by a decrease, in the *variation* of measurements of growth. While comparatively little is known of the factors responsible for the sudden changes in growth rates, the increase and subsequent decrease in the variability of measurements are attributed, (2) generally, to *variation in chronological age* at which the acceleration begins and ends in different individuals. At the present time, factors which may account for the differences in age at which the acceleration and deceleration take place are not clearly understood. On the basis of previous work on the physical resemblance of siblings it may be supposed that certain critical points in the progress of growth, for example, the age at which the acceleration begins, occur at more nearly the same age in brothers (or sisters) than in unrelated children. If a similarity of growth patterns in siblings is observed, and can be quantitatively evaluated,

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it would be possible to determine what portion of the increased variability in growth measurement of children in general is due to variation between siblings and what portion is due to variation between individuals not so related. Fisher (4) gives a discussion of this problem. A somewhat indirect but logical approach to this problem would appear to be feasible through an analysis of the correlation of measurements of brothers (and sisters) as they pass through the same successive critical ages. If this correlation of measurements remains relatively constant throughout the adolescent period, it may be that the time of acceleration and deceleration in growth occurs at approximately the same age in siblings of the same sex. On the other hand, if a change in the correlation of measurements is found, the extent of this change will furnish not only further detail of the nature of fraternal resemblance but will furnish, as well, some data for the quantitative determination of a further source of variability in growth processes.

Other questions of interest to the student of human growth arise as a result of a consideration of the resemblance of siblings. Thus, such pertinent questions may be asked: Are there sex differences in age changes of fraternal resemblances? Does order of birth influence fraternal resemblance? Are siblings widely separated in actual age more or less similar than siblings of nearly the same age? What effect does age of parents at the birth of their children have upon sibling resemblance?

An exhaustive study of even these relatively simple problems would require the amassing of a great deal of data not easy to collect. Entirely satisfactory material probably can be obtained only by taking long-time serial measurements of a great many siblings. So far as the writer is aware, no such body of data is available at the present time. However, in the course of an extensive investigation of the growth of children, undertaken by the Office of Child Hygiene of the U. S. Public Health Service at Hagerstown, Md., during the years 1921–28, material has accumulated from which it is possible to make a preliminary analysis of certain problems dealing with sibling resemblance.

This material includes, among other things, measurements of height and weight, recorded at least for 4 successive years, of approximately 2500 white children who attended the elementary grade schools of Hagerstown during 1921–1928. All of these measurements were made by trained field personnel of the U. S. Public Health Service and nearly 90 per cent were made by the same person. Height was measured in the erect standing position, without shoes, to the nearest $\frac{1}{4}$ inch, according to the technique prescribed by Hrdlička (7). The same measuring board was used throughout the whole period of observation. Weight was measured on carefully calibrated beam scales to the nearest $\frac{1}{4}$ pound and included the regular indoor clothing except shoes, coats, sweaters and vests. All measurements of weight used in this study were recorded in May in the successive school years and, although not precisely on the same day in May each year, the interval between weighings is considered sufficiently exact for the purposes of this study. Measurements of height were made in the spring months and where the interval was not exactly one year, arithmetic interpolations were made. For the classification of age, all children were grouped in single years of life as of the birthday nearest January 1 of the school year in

which they were measured. For further information concerning details of the general investigation the reader may consult references (8, 9, and 10).

In the course of this 7-year investigation the height and weight of 193 pairs[2] of brothers and 154 pairs[2] of sisters were measured one or more times *when the two brothers (or two sisters) were of the same chronological age.* Thus 80 brothers were weighed when both were 7 years of age, 117 brothers were weighed when both were 8 years of age, the height of 63 brothers was measured when both were 7 years old, the height of 104 brothers was measured when both were 8 years old, and so on.

From these data it was possible to make correlation tables, specific for each age from seven to twelve years, of the height and of the weight of pairs of brothers and pairs of sisters. Thus the weight of older brother was correlated with weight of younger brother, when both were 7 years old, the weight of the older brother was correlated with the weight of the younger brother when both were 8 years, and so on. The original data on which the study is based did not include notations of birth order. The analysis is limited, therefore, to correlations of older and younger siblings, regardless of order of birth. Also, no account could be taken of the actual difference in age of the siblings but, because the period of observation extended only over 7 years, the greatest difference in actual age does not exceed 7 years. On the average the difference in ages of the paired brothers (and sisters) equals approximately 3 years.

The results of the analysis of the separate correlation tables are summarized in table 1. This table shows, specific for the 2 sexes, specific for each age from seven to twelve years, and specific for heights and for weights, the mean and standard deviation of the measurement of the older sibling, the mean and standard deviation of the measurement of the younger sibling, and the observed and "corrected" correlation coefficients, the Pearsonian *r*, for the measurement on the two siblings. Individuals placed in a single age class are not precisely of the same age, i.e., those grouped in the 7-year class included those between $6\frac{1}{2}$ and $7\frac{1}{2}$ years of age. Thus, of a pair of brothers entered in one table, one might have been just more than $6\frac{1}{2}$ years of age and the other just under $7\frac{1}{2}$ years. The effect of such grouping would tend, clearly, to give coefficients less than those which would have been obtained had all brothers been exactly of the same age. A simple method of correcting for this difference has been proposed, (see Boas (2) and Berkson (1)) and was used in the determination of the "corrected" coefficients.

In table 1 are given also the means, standard deviations and number of cases for measurements of height and weight of a large group of boys and girls who were measured in Hagerstown during the period of investigation

[2] None of these pairs was twins. In a few cases there were 3 siblings in the same family, but in only 10 instances were there measurements on all three siblings at the same age. In each of these 10 cases, the three possible pairs of measurements were used but no account was taken of the fact that they were not independent. It was assumed, however, that no significant error would be introduced by treating these observations as independent.

TABLE 1

Constants derived from correlation tables of heights, and weights of brothers, and sisters; constants derived from frequency distributions of heights, and weights of all boys, and all girls. Elementary school children, Hagerstown, Maryland, measured during 1921–28

AGE	NUMBER OF PAIRS OF SIBS	MEAN		STANDARD DEVIATION		CORRELATION COEFFICIENT		MEAN	STANDARD DEVIATION	NUMBER OF CASES
		Older sibs	Younger sibs	Older sibs	Younger sibs	Observed	Corrected			
		Brothers (weight in pounds)						All boys (weight in pounds)		
7	80	48.87	49.15	6.25	5.57	.48	.50	50.63	6.44	596
8	117	53.97	54.46	6.46	6.12	.44	.46	55.97	7.38	839
9	168	58.84	59.36	6.90	6.65	.38	.40	61.57	8.71	987
10	149	64.35	64.58	8.05	8.03	.38	.40	67.22	10.53	992
11	103	71.08	72.15	10.16	10.03	.36	.38	73.91	12.36	868
12	63	78.11	78.06	12.15	11.02	.38	.40	80.98	15.01	681
		Sisters (weight in pounds)						All girls (weight in pounds)		
7	63	48.03	46.56	6.60	5.28	.32	.33	49.11	6.25	573
8	107	53.39	51.97	7.34	5.79	.33	.34	54.18	7.51	811
9	127	58.86	57.15	8.84	7.55	.25	.26	59.50	9.25	921
10	129	64.48	64.26	9.70	9.76	.24	.25	66.07	11.50	925
11	82	71.44	72.00	12.17	13.29	.25	.27	74.10	14.29	798
12	37	78.57	82.49	16.55	14.43	−.02	−.02	84.12	16.22	614
		Brothers (height in inches)						All boys (height in inches)		
7	66	46.00	46.17	2.20	1.89	.58	.63	46.27	2.15	710
8	104	48.02	48.39	2.29	1.81	.42	.46	48.48	2.19	851
9	129	50.48	50.15	2.28	1.95	.54	.59	50.63	2.28	977
10	154	52.18	52.12	2.18	2.13	.40	.43	52.47	2.38	1034
11	106	53.97	53.85	2.52	2.22	.37	.39	54.32	2.52	898
12	65	55.86	55.49	2.62	2.41	.55	.58	56.15	2.64	734
		Sisters (height in inches)						All girls (height in inches)		
7	64	45.70	45.45	2.18	2.65	.52	.56	45.80	2.10	679
8	79	48.22	47.73	2.12	2.39	.43	.47	48.02	2.17	797
9	118	49.96	50.01	2.34	2.49	.39	.41	50.06	2.30	909
10	123	51.96	51.84	2.23	2.34	.27	.28	52.13	2.39	960
11	93	53.97	54.03	2.60	2.65	.24	.26	54.23	2.70	859
12	37	56.03	56.03	2.98	2.77	.18	.18	56.62	2.99	654

(1921–28). These data furnish standards with which the measurements of the siblings will be compared.

RESULTS

Correlation of siblings. Figure 1 shows graphically the variation with

age of the corrected coefficients of correlation. A considerable amount of irregular fluctuation in the coefficients is apparent. It may be noted, however, that the coefficients tend to be higher for brothers than for sisters, and that those for height are higher than those for weight. For brothers the average of the coefficients of correlation for all ages for both height and weight together equals +0.47 while a similar average for sisters equals +0.30. The average coefficient, all ages, of height for both brothers and sisters together is +0.44 and that for weight is +0.33.

The standard deviations of random sampling of the individual coefficients vary from 0.05 to 0.17. With these large sampling errors it is not possible, unfortunately, to evaluate with precision the age trends of the correlations for height, and weight, for brothers and sisters separately. Nevertheless, one fact can be noted, namely, *that the degree of correlation tends to decrease with advancing age during this period of growth.* The averages of the coefficients of height, and weight, for brothers, and for sisters, for the successive age classes are as follows:

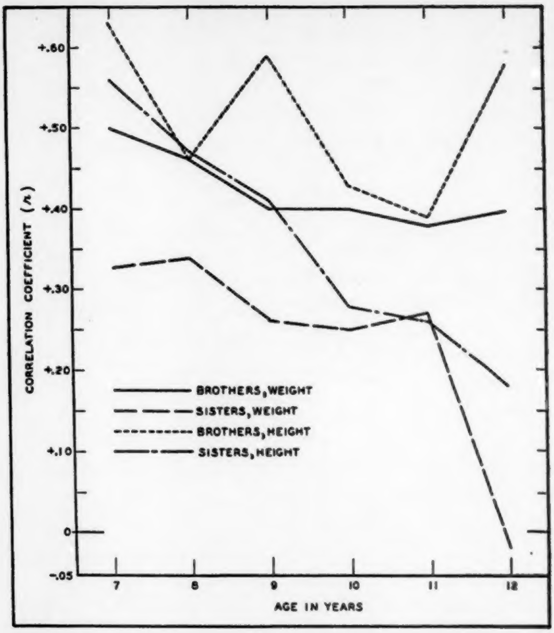

FIG. 1. CORRELATION COEFFICIENTS, SPECIFIC FOR AGE, OF THE HEIGHTS AND OF THE WEIGHTS OF SIBLINGS

7 years	+ .51
8 years	+ .43
9 years	+ .42
10 years	+ .34
11 years	+ .33
12 years	+ .29

The age change in this series of coefficients, while not great, indicates without much doubt that the resemblance of siblings of the same sex tends to become less with increasing age. According to these data the downward trend is fairly uniform during the whole period. Although the ages under observation do not extend far into the period of adolescent accelerated growth, there is no conclusive indication that the beginning of the accelerated phase, approximately 10 years in girls and 11 years in boys, is associated with a marked decrease in sibling resemblance. Taking all of the evidence at hand, however, it is fairly conclusive that the average correlations of these physical measurements of siblings at 12 years of age is probably not much greater than that implied by a correlation coefficient of +0.30. Pearson and other investigators have shown, and their findings are generally accepted as correct, that the physical resemblance of adult siblings is represented approximately by a coefficient of +0.50. If it can be assumed that the coefficient of +0.30 at 12 years is approximately correct it is clear that during the adolescent period siblings resemble each other considerably less than they have at an earlier age, say 7, and also, considerably less than they will at a later age, say in early adult life.

Another view of the change with age in general physical resemblance of siblings can be obtained through an analysis of variation. Suppose a large number of pairs of children of the same age and sex be drawn at random from the general population and an average measure of the differences between the pairs be expressed in terms of the average root mean square difference between their measurements. If σ denotes the standard deviation of the measured character, σ_u the average root mean square difference between 2 children, and r the correlation of the measurements of the two children, then the following well known formula may be written

$$\sigma_u = \sqrt{\sigma^2 + \sigma^2 - 2\sigma^2 r}$$

In case two unrelated children are drawn at random, r equals zero and the equation becomes

$$\sigma_u = \sqrt{2}\,\sigma$$

In case pairs of siblings are drawn at random from the population, assuming that the standard deviation of siblings is equal to the standard deviation of children in general, σ_{us}, the average root mean square deviation of siblings is

$$\sigma_{us} = \sqrt{2}\,\sigma\sqrt{1 - r}$$

The variability of two siblings drawn at random compared with the variability of two unrelated children can now be expressed in relative terms as the ratio

$$\frac{\text{Variability of siblings}}{\text{Variability of unrelated children}}$$

i.e.,

$$\frac{\sigma_{us}}{\sigma_u} = \frac{\sqrt{2}\,\sigma\sqrt{1 - r}}{\sqrt{2}\,\sigma}$$

or,

$$\frac{\sigma_{us}}{\sigma_u} = \sqrt{1 - r}$$

When r is set equal to +0.5, the estimated average value of fraternal cor-

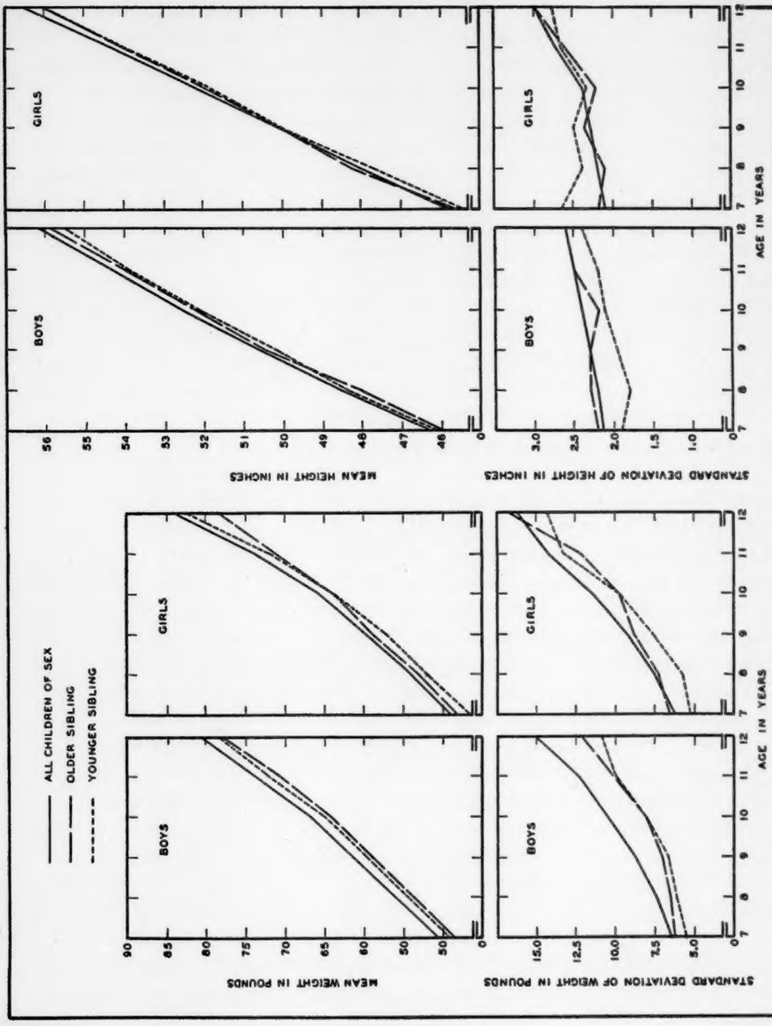

FIG. 2. MEANS AND STANDARD DEVIATIONS OF HEIGHT AND WEIGHT OF SIBLINGS COMPARED WITH THE MEANS AND STANDARD DEVIATIONS OF ALL CHILDREN

Elementary school children, Hagerstown, Maryland, measured during 1921–1928

relation at 7 years (and also adult life), $\frac{\sigma_{us}}{\sigma_u}$ becomes approximately .7 or 70 per cent. From this viewpoint, then, two siblings, drawn at random from the population of 7 year olds (or young adults) will show 70 per cent as much variation as two unrelated individuals drawn from the same population. When r is set equal to 0.3, the estimated value of the fraternal correlation at 12 years of age, the relative variability of siblings compared with unrelated individuals is

$$\frac{\sigma_{us}}{\sigma_u} = \sqrt{1 - .3} = .84 \text{ or } 84\%$$

Thus at 12 years of age the variability of siblings is 84 per cent as great as the variability of unrelated children. According to this somewhat arbitrary and obviously general view of the problem, at 7 years of age and again in adult life, siblings are 30 per cent less variable than unrelated individuals, while at 12 years of age siblings are only 16 per cent less variable than unrelated individuals.

With some caution, two conclusions may be drawn. First, at the age of 12 years brothers (and sisters) are more dissimilar in respect to height and weight than they were at 7 years of age and, also, that at 12 years they are more unlike, with respect to the same measurements, than they will be as adults. In other words, the growth patterns of brothers (and of sisters) are not identically similar on the scale of chronological age. The second conclusion, and this follows as a corollary from the first, is that at least a part of the variability of measurements of growth observed in studies of large groups of children is due to the differences in the growth patterns of hereditarily similar individuals, e.g., brothers and sisters.

As has been noted above, it would be of considerable importance to make a precise quantitative estimate of the portion of the variation of measurements of growth that may be accounted for from the two sources, first the variation arising as the result of differences of growth of siblings, and second, variation arising as a result of differences in growth of individuals not of similar heredity. Unfortunately, in view of the fact that the constants derived are subject to such large sampling errors, it seems wise to reserve such a quantitative analysis until more extensive and precise data are available. In this connection, it may be stated that further data are being collected which, when completed and analyzed, may be expected to furnish more conclusive and comprehensive results.

Height and weight of siblings compared with those of all children. In figure 2 the means and standard deviations of measurements of siblings are compared graphically with similar constants for all of the children measured in the Hagerstown investigation. With respect to weight, the averages at each age and the standard deviations at most ages are less for the siblings than for the total group of children. On the whole, the differences between the siblings and other children are larger and less irregular for boys than for girls but in general it is apparent, in this group of children, that boys who have brothers and girls who have sisters are both lighter and less variable in weight than the general population

of boys and girls. With respect to height, the averages for the brothers are slightly but consistently less than those for the other boys; the averages for the sisters are more irregular but there is some evidence that girls with sisters in the group measured tend to be shorter than those without sisters. The standard deviations of the heights of the siblings fluctuate with some irregularity about those for other children and it must be concluded that variability of heights of siblings is not significantly different from the variability of heights of children in general.

A possible explanation of the difference between boys and girls in the general population and boys who have brothers and girls who have sisters may be due to the combined operation of differential fertility rates and growth rates of children from different economic levels. It has been shown by a number of investigators that children from the poorer economic classes are on the average lighter in weight and shorter in height than children from families in the better economic classes. It has been shown also that families of the poor tend to be larger than families of the more well-to-do. Although no quantitative evaluation of the operation of these factors can be given it seems not improbable that the observed difference of the siblings may be due to the differential selection of a large proportion of siblings from the lower economic groups.

SUMMARY

This study, based on measurements of height and weight of siblings at successive ages, shows that the coefficients of correlation of height and of weight of brothers and of sisters decrease with increasing age from the 7th to the 12th years. In the light of previous work on adult siblings, together with the result presented here, it is concluded that fraternal resemblance of physical characters is less at 12 years of age than it was earlier in life, say age 7, and less than it will be later, say, in early adult life. Study of the heights and of weights of siblings shows that boys that have brothers and girls that have sisters tend to be lighter in weight and slightly shorter in height, on the average, than a large group of boys and girls in the general population. The siblings measured tend also to be less variable in weight than the general group of boys and girls.

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A Comparison of the Abbreviated and the Complete Stanford Revision of the Binet-Simon Scale

LENOIR H. BURNSIDE

A CHILD of fifteen years seven months of age was given the Stanford Revision of the Binet-Simon Scale. Different methods of calculating the mental rating gave the following results: mental age—15 years 3 months, 16 years 8 months, or 17 years 2 months; intelligence quotient—98, 107, 109, 110, 119, or 123. If these diverse ratings had been secured by the use of different tests the difficulty of interpretation might be met by following the oft-made suggestion of labeling the result, *e.g.*, Kuhlmann mental age or Otis S. A. intelligence quotient. This is not the case: the above ratings were all obtained from one examination using the Stanford Revision of the Binet-Simon Scale. It is obvious that in the use of this scale more detailed labeling is advisable. These diverse ratings were obtained for mental age by using (a) the abbreviated form of the scale (starred tests on the blanks furnished by the Houghton-Mifflin Co.), (b) the complete scale, (c) the complete scale with the Terman correction (6) for the upper years of the test. Each of these mental ages yields an intelligence quotient with any chronological age used as the adult level of mental maturity. In this example chronological age levels of fourteen and sixteen years were employed as they are the more common in clinical practice. We have here then two sets of ratings determined by the use of the abbreviated or the complete scale of the Stanford Revision of the Binet-Simon tests. This observation of an actual case raised a number of questions in regard to the use of the two scales for clinical purposes.

Is there a significant difference in intelligence rating of individuals on the complete and on the abbreviated scales? If so, what per cent of individuals are affected? What constitutes a significant difference? Does this difference have a constant direction: (a) rated higher by the abbreviated scale; (b) rated lower by the abbreviated scale? What factors predicate this difference: (a) Chronological age, (b) mental age, or (c) intelligence quotient? Are the two scales equal in value for clinical purposes? If the results obtained by the two scales are so nearly identical as to be interchangeable, then for practical reasons the shorter of the two scales is the more desirable. It would materially lessen the time necessary for an examination and thereby make possible an increase in the number of subjects seen. This economy of time is of no

small moment in school or court clinics where examinations are made under the heavy pressure of hundreds of cases.

This need for a reduction in time required for the giving of the complete Stanford Scale has prompted several investigators to devise abbreviated scales. Doll (2) made a selection of tests from the complete scale which "should exaggerate mental retardation in mentally defective subjects but would leave the mental level of normal subjects unaffected." For this scale he chose two tests per year from years V to X inclusive. The selection of the tests was based upon data from the examinations of 88 normal subjects, chronological age five to ten years, and 189 feeble-minded, mental age five to ten years with average chronological age 20 years. He states that "mental ranks will have practically the same reliability for the normal subjects as for the feeble-minded subjects, but the mental age values for the feeble-minded subjects will be from 5 to 10 per cent lower by the brief scale." Correlating mental ages on the two scales he obtained a correlation of .98 for the normal subjects, and .90 for the feeble-minded. Subsequently he selected "on the basis of experience" two tests per year for years III, IV, XI, and XII. This scale he suggests for use in the first five grades of the public schools.

Just after the war several other investigators reported experiments in devising brief scales made up of selections of test items from the complete Stanford-Binet Scale. These scales were developed to meet special conditions of psychological examining in the army. Lincoln, and Cowdery (4) reported on a scale made up of two tests per year. In this study there were 486 soldiers. The author points out that the order of difficulty of the tests for soldiers differs from that for school children. The conclusions from the studies of the briefer army scales have no value in our present investigation, not alone because of differences in subjects but also in scales under consideration. The complete army scale was itself an abbreviated scale made up of only four tests per year, not the same as the four starred tests of the Stanford-Revision blank.

Aside from the reports already mentioned of brief Stanford-Binet scales the only other found was that by Brooks (1). He used for a brief scale the four starred tests of the Stanford-Revision blank. The data given are of 575 individuals, chronological age range six to seventeen years inclusive. Although not specifically stated by the author it may be assumed from chronological age range that the subjects were school children. Brooks reports that the group as a whole was below normal. The differences in intelligence quotients on the two scales range from -33 to $+31$ points. The middle fifty per cent of differences is from four to seven points. After analyzing his data he concluded that the "abbreviated Stanford-Binet gives intelligence quotients from two to four points less accurate than those of the complete scale" and that "the abbreviated scale is almost as accurate as the complete scale, whether it be used to determine an individual's intelligence quotient or the relative mental standings of a group."

The data used in the present report

consist of the individual examination records of 375 pupils in the public schools of Rochester, N. Y. These pupils were those referred to the psychologist for aid in educational and vocational guidance, for the correction of some behavior or personality difficulty, or merely because parents wished to take the opportunity offered for psychological counsel, or because the pupils themselves requested it. Each year level for adult intelligence was used. The two sets of values thus obtained were then compared. Terman's correction (6) for the upper ranges of the test could not be used as data, for proportionate values to be added in using the abbreviated scale could not be obtained. The use of this correction would in some cases result in even greater differences than are here reported.

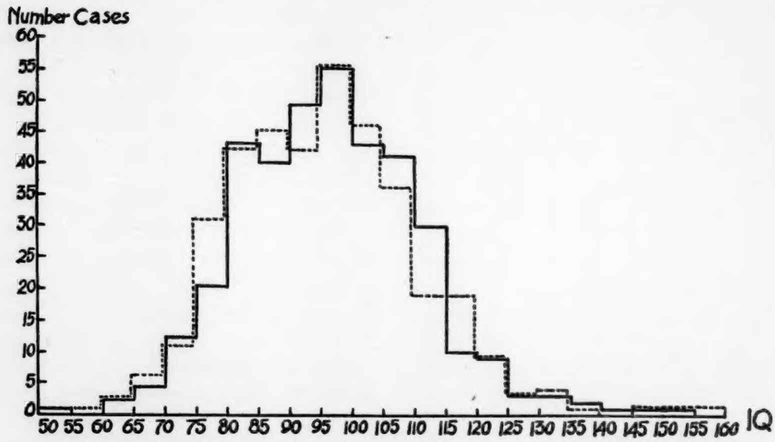

Fig. I. Distribution of Intelligence Quotients

pupil was given the complete form of the Stanford Revision of the Binet-Simon Scale. These complete test records were then re-estimated as if only the starred tests of the scale had been used. Throughout this paper the tests starred on the Stanford Revision of the Binet-Simon test blanks furnished by the Houghton-Mifflin Company form the abbreviated scale of the report. In calculating the intelligence quotient for the upper ages the sixteen

The chronological age range of the group was 11 years 2 months to 20 years 8 months inclusive. The mental age range on the complete scale was 8 years 6 months to 19 years 0 months; on the abbreviated scale 8 years 9 months to 19 years 6 months. The range of intelligence quotients on the complete scale was 53 to 154; on the abbreviated scale 55 to 156. Rated by either scale approximately fifty per cent of the group fall within

the limits of normality as defined by Terman (5). The distribution shown in figure 1 follows rather closely the normal curve whichever of the two scales is used.

TABLE 1

Differences in intelligence quotients, abbreviated minus complete scale rating. Three hundred and seventy-five cases

DIFFERENCES IN IQ	FREQUENCY	TOTAL FREQUENCIES IN EACH GROUP	PER CENT OF TOTAL NUMBER OF CASES
−14	1		
−13			
−12	2		
−11	3		
−10	2		
−9	3	66	17.60
−8	7		
−7	11		
−6	17		
−5	20		
−4	17		
−3	25		
−2	25		
−1	35		
0	36	273	72.80
+1	40		
+2	38		
+3	30		
+4	27		
+5	9		
+6	12		
+7	7		
+8	3		
+9	2		
+10	2	36	9.60
+11	1		
+12			
+13			
+14			

Table 1 shows the distribution of the differences in intelligence quotients when the intelligence quotients obtained on the complete scale are subtracted from the intelligence quotients obtained on the abbreviated scale. It is seen that 273 cases or about 73 per cent show a difference of less than five points. This amount of variation may be assumed to be insignificant unless consistently in the same direction. Therefore, in the large majority of cases the two scales give quantitative results approximately equal. This finding is in agreement with Brook's (1) statement that the abbreviated scale is almost as accurate as the complete scale to determine the relative mental standings of a group. This quantitative similarity may, however, conceal qualitative differences of great significance for individual diagnosis. The equivalence in mental age rating cannot be construed as diagnostic equivalence. Subject S. B. is illustrative of cases where the quantitative difference is insignificant but where the qualitative differences are significant for the clinical psychologist. This girl's chronological age was 16 years 4 months. She failed test 3, one of the unstarred tests, in year XII. Performance on this test was too poor even for credit at the eight year level. Because of this failure it was necessary to go back as far as year VI for a basal year. If only the abbreviated scale had been used year IX would have been the basal year. The total quantitative difference of 2 points in intelligence quotient was not significant, but the knowledge of the subject's failure on test 1 in year VIII and tests 2 and 6 in year VII, these latter two starred tests, would be worthy of consideration in a clinical diagnosis for educational guidance. The intelligence rating itself does not furnish sufficient means for mental diagnosis.

A difference of five or more points in

intelligence quotient is assumed to be a significant difference. This amount is an arbitrary one chosen because it covers half the range of any of the Terman classification groups except that of the normal. From table 1 it is seen that 102 cases or 27 per cent vary to this amount. The range of this variation is from −14 to +11 points in intelligence quotient. Quantitative differences among this 27 per cent appear sufficiently great to be of importance in any study of an individual. The range of variation reported in this investigation is not as great as that reported by Brooks (1). In the process of analyzing his data Brooks seems to have overlooked the individual in his effort to discover the general agreement between the two scales under consideration.

It may be interesting to give here several cases having what the author considers a significant absolute difference in rating. Interesting diagnostic differences will be noted also. Case number 1, R. F. boy, chronological age 14 years 5 months. Using the complete scale the basal year is VII, but using the abbreviated scale the basal year is X. In this case not only is the quantitative difference of 8 points in intelligence quotient large enough, perhaps, to be considered significant, but also for an analysis of the subject's possibilities and limitations it is valuable to know that he fails in test 1 year VIII, test 6 year IX, test 3 year X, test 3 year XII, and that he succeeds in test 2 year XII and test 2 year XVI.

Case number 2, A. G. girl, chronological age 16 years 9 months. In the upper years of the test it is fairly common practice, in cases where good rapport between the psychologist and the subject has been established, to begin the examination with the vocabulary test, and to proceed from the year level indicated by the rating obtained on this test. If this were done in the case of A. G. using only the abbreviated scale the mental age rating would be 11 years 0 months, intelligence quotient 69; but using the complete scale successes on both unstarred tests in year XIV, all other tests of this year having been failed, leads one to continue. The successes in year XVI and year XVIII are starred tests. Her achievement in school and her social adjustment indicate that the rating obtained by use of the complete scale more accurately represents her intellectual level.

Case number 3. Likewise in the case of M. N., chronological age 13 years 8 months, mental age obtained by use of the abbreviated scale only would have been 11 years 5 months with an intelligence quotient of 84. This would be 11 points lower in intelligence quotient than that obtained by the complete scale. In using the abbreviated scale all starred tests in year XIV were failed, yet there were successes on starred tests in years XVI and XVIII. These would not have been discovered in using only the abbreviated scale, for the examination would have stopped at year XIV.

Case number 4. On the abbreviated scale the intelligence quotient for C. W. was 14 points lower than on the complete scale. Beyond the XII year group of tests there were six successes, five of which were not included in the abbreviated form. An analysis of these successes in a clinical diagnosis

may be of more value even than the very large variation in intelligence quotient would suggest.

Does the difference between the two forms of the scale have a constant direction so that it may be corrected by conversion constants? Table 1 shows 168 cases rated lower by the abbreviated scale, 66 of these, or 39 per cent are five or more units lower; 171 cases are rated higher by the abbreviated scale with 36 of these, or 21 per cent, five or more points higher. It is thus seen that the difference in intelligence quotient between the two scales does not tend in any constant direction for the group under consideration; so cannot be corrected by conversion constants.

What is the relation of this difference to chronological age? The correlation coefficient of difference in intelligence quotient with chronological age is found to be $-.08$ P. E. $\pm.03$. This is practically zero correlation and indicates that the younger and the older children are equally affected by the change of scales.

What is the relation of difference in intelligence quotient on the two scales to mental age on the complete scale? The coefficient of correlation here is $-.10$ P. E. $\pm.03$. Thus it is seen that the subjects below and those above average in mental age rating are affected about equally, for no significant correlation exists between the two.

The correlation coefficient for differences of intelligence quotient on the two scales and the intelligence quotient on the complete scale is $-.07$ P.E. $\pm.03$. Here again the correlation is insignificant. This indicates that for this group the brighter and the duller children are about equally affected.

Correlations between the two test series were not computed. It has been pointed out (3) that correlations obtained whenever the measurements obtained from one set of data are included in those of the other set are spurious correlations. Since the brief scale is exactly two-thirds of the complete scale a very high correlation between the two would be inevitable. But it would be a spurious correlation. Such are many of the correlations of .90 and above reported in previous studies of the abbreviated scales of the Stanford Revision of the Binet-Simon Scale.

In treating statistically the data from the two sets of measurements one learns that for about three-fourths of the cases the briefer form gives results similar to the complete form. But for the other fourth the variation is significantly great. Which of the two scales is the more valid has not been determined. However, in a statistical treatment of data one is apt to overlook the individual in the process. A study and diagnosis of individual differences is the primary object of clinical psychology. It is generally agreed that the greater the variety of standard situations the less likelihood of invalidation due to environment or to educational opportunity. For this reason the complete scale is to be preferred to the abbreviated scale for subjects presenting exceptional or puzzling problems. Terman writes: "The brief form is by no means as reliable as the entire scale. It should be used only when it is absolutely impossible to make a complete test." In a letter to the author of this paper he states also that data on which he bases this conclusion or on which the starred tests were selected have not been published.

SUMMARY

This paper is a report of differences in mental rating obtained by using the complete Stanford Binet Scale and the abbreviated Stanford Binet Scale, starred tests on the Houghton-Mifflin Company blanks of the Stanford Revision. The data are from 375 examinations of public school children whose chronological age range is 11 years 2 months to 20 years 8 months inclusive. The purpose is to emphasize some of the differences significant for individual psychology. The group on which the data are computed shows a normal distribution in intelligence ratings as determined by the Stanford Revision Scale.

A difference of five points is arbitrarily chosen as a significant difference in intelligence quotient because it covers one-half the range of any of the Terman classification groups except that of the normal.

A significant difference in intelligence quotient is found in 27 per cent of cases when ratings obtained by the complete and abbreviated scales are compared.

There is no constant direction of difference in intelligence quotient between the two scales for the group under consideration. Therefore, no correction constant may be used.

The correlation between chronological age and intelligence quotient differences shows the younger and the older children equally affected by the change of scales. Subjects above and subjects below average in mental rating are equally affected by the change in scales. The brighter and duller children as judged by intelligence quotient ratings on the complete scale seem to be about equally affected by use of the abbreviated scale.

The variation in intelligence quotient between the two scales is insignificant for about three-fourths of the group. Variation for the other fourth is large enough to be considered significant.

Qualitative differences may be great enough to be worthy of note for clinical diagnosis even when quantitative differences are small.

In conclusion, the more extended form of the scale is to be preferred to the abbreviated form for use in making a clinical diagnosis of an individual.

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A Study of Attention in Young Children[1]

Mary Frances Bestor

ALTHOUGH studies of the attention of young children have been few in number, a technique of observation has been developed. This involves diary and time records of the behavior of young children in certain somewhat controlled manipulations similar to, if not identical with play. In general, these studies have defined attention span as synonymous with activity span, and have not distinguished between activities to which attention is actually directed and those which merely continue if uninhibited.

Mueller and Pilzecker in 1900, according to Foster (4), pointed out that ideas possess a perseverative tendency which generally passes rapidly away, but which, when attention is directed intensely upon the idea, strongly persists. There is considerable difference of opinion as to the significance of this factor. Foster's (4) study revealed no facts in support of the assumption that such a tendency to perseveration exists. Lankes (5), on the other hand, found that there is a distinction between perseveration through the nervous system, and persistence through actual effort and individual will power.

Cushing (2) made a study of the tendency in preschool children, defining it as a particular drive of the organism toward continuous activity of an organic pattern once aroused. She found a common factor throughout the occupations of young children involving manipulative materials of a simple repetitive sort, which may be accounted for by perseveration. The writer herself points out that it is impossible to be sure to what extent the perseverative tendency is coterminous with "interest in manipulation," a common factor in activity situations of this nature.

In order to limit the scope of the present investigation, attention has been defined in as limited and as specific a fashion as possible. Dashiell (3) has defined it as the attitude facilitating the response of an individual to some particular stimulus or stimuli. This definition which restricts the range and nature of stimulation and rules out the tendency to perseveration, has served as a guide to the interpretation of the term throughout the investigation.

In order to differentiate between attention and interest in activity it seemed advisable to select materials that would be meaningless. Just as nonsense syllables have been devised to test learning, so it was thought that nonsense visual and auditory stimuli could be devised to test attention. To render a visual stimulus meaningless it

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is necessary to get away from color and pattern. For a meaningless auditory stimulus it is necessary to eliminate melodic and rhythmic pattern. Because it is so difficult to isolate tactual, olfactory and gustatory stimuli, they have not been included in the present investigation. The ommission of tactual stimuli was made with a definite purpose in view, namely to eliminate manipulation in order to minimize as much as possible the tendency to perseveration.

THE EXPERIMENTAL SITUATIONS

The experiment involved three distinct series of situations, an original experiment and the repetition of two previously published experiments. The test devised to meet the requirements for a meaningless visual stimulus presented a colorless light shining behind an irregular, opaque field about two square feet in area. The light flashed off and on, at short and irregular intervals. It was placed behind a screen so that it could be observed only from a limited area of approximately 12 square feet. While the child was within this area he was considered to be reacting to the stimulus, but he was free to move about the room as much as he wished. There was nothing else in the room during the experiment. With half of the subjects the visual situation was presented twice. The general outline of the field of light differed in the two situations, but both were, to all intents and purposes, meaningless.

The problem of finding meaningless auditory stimuli was more difficult, but a solution was presented by the Victrola records of the Seashore test for pitch discrimination, in which there is scarcely any rhythmic pattern and the changes in pitch follow no melodic pattern. Each Victrola record took three and a half minutes to play and there was no explanatory comment to offer distraction. Short of actually constructing records, there was no more suitable material available. The Victrola was started before the child entered the room, and was placed out of sight in a closet. In only a few cases was it necessary to play more than one side of the disc, and with the exception of these cases the child did not see the instrument at all. The door into the hall was left open to permit freer movement in and out of the range of the auditory stimulus. There was nothing in the room, and the duration of the attention span was recorded as the time spent in the room.

A study by Shacter was selected for repetition because it purported to be a test of attention, although, in the writer's opinion, the behaviour measured was not limited to attention but included interest in manipulation and perseveration, as well.

Shacter (6) defined attention span simply as the time during which a given activity continues without external compulsion or persuasion. In trying to eliminate situations in which a goal was implicit, she chose materials which would lend themselves to repetition in manipulation tending to indefinite perpetuation. She found no appreciable difference in the length of the attention span at the three levels, but found an increased span in proportion to the complexity of the activity.

In a second study, Shacter (17) attempted to find out whether or not

there was a relationship between intelligence and attention span, as was suggested by the dependence of the length of the period upon the complexity of the activity. A rating was obtained through a composite scale made up of the verbal tests from the Stanford-Binet series, a performance test from the Merrill-Palmer series, and a picture pointing test from the Detroit Kindergarten series. Her hypothesis was not supported by the results, which indicated that some other factor than mental ability is operative. The principal criticism which can be made of such studies of the attention of young children is concerned with the basic assumption that attention span is synonymous with duration of activity.

The two situations selected were chosen because they seemed most suitable to the age group which was to be observed, not because of any preference expressed by the original experimenter. In addition to the time records, a detailed account of the type of manipulation, color and form discrimination, and the comments, both relevant and irrelevant made by the subjects, was recorded at the time of observation.

To provide a measure of the perseverative tendency, the auditory and the visual experiments of Cushing's study were repeated. The two situations selected, namely the visual and the auditory, were chosen as those most nearly corresponding to the type of situation to be presented in the third part of the experiment. Diary records as well as time records were kept during this series also. The two tests were presented on the same day, the auditory invariably preceded the visual.

The third series consisted of the visual and auditory situations described at the beginning of this section. In the Cushing and Shacter experiments the child's performance was preceded by demonstration. The present experiment required no demonstration since no manual response on the part of the child was necessary. No directions were given except immediately preceding the experiment. In the visual situation the child was told that there was something he might see if he looked behind the screen. As soon as the child passed the screen and came within the area where the light was visible the stop watch was started and was not stopped until he left that area. No further remarks were made by the experimenter except in answer to individual questions. In the case of the auditory stimulus, before the child entered the room he was told there was something which he might hear. A record was kept of the time spent in the room itself. In a few cases it was necessary to say to the child that he might leave the room when he was through looking or listening. A record was kept of all such instances together with the circumstances preceding and the child's reaction.

Each child was observed in each of the 3 series, and in every case, but 1 series was presented on a single day.

Teacher's Rating Scales

To provide a means for evaluating the traits which were being measured by the original experiment, a rating scale was devised by which each child was rated by three Nursery School

teachers. The following statements were graded as to their applicability to the behavior of each specific child, on the basis of a five-point scale:

1. He attends to one thing for a long time.
2. His attention is attracted easily.
3. His attention is distracted with difficulty.
4. He always finishes an activity begun.
5. If interrupted, he returns to the original activity.

If the description of behavior were exceptionally true of the individual's behavior he was rated 5, if exceptionally untrue 1; merely average manifestation of the behavior was graded 3. Thus there was a possible range of from 5 to 25 points per child per observer. Since Conrad (1) found that no matter how significant the factor of skewness might be in individual judge's ratings, the significance practically disappeared if three or more judges' ratings were averaged, the final score for each child was the average of the three teachers' ratings.

The Subjects. The subjects for this investigation were drawn from two sources. In each group there were 7 four year olds, 8 three year olds and 3 two year olds. The first group, which will be designated as Group I, consisted of eighteen children from the Mills College Nursery School between the ages of twenty-nine and fifty-eight months. In Group I age was not a selective factor. The group as a whole had had several months together, were familiar with the part of the building in which the investigation room was located, and were in daily contact with the experimenter in the regular routine of the Nursery School. The selective nature of the enrollment provided that, as far as family background was concerned, this was a fairly homogeneous group, if not a widely representative one.

Group II, on the other hand, was drawn from an Emergency Nursery School which was held in the Mills College Nursery School building in the afternoons. The 18 children were selected as most nearly approximating the ages of the corresponding children in Group I. The age range was from twenty-nine to fifty-five months. Group II forms a heterogeneous group as to the economic and educational background of the families represented. The requirement for admission to the Emergency Nursery School was an income as low as that required by the county for relief, but the vocational training of the fathers ranged from day laborers up to the professional class. The majority of the fathers were unemployed except for part time. Some of the parents had had as little as six years of elementary school, while others had had as much as five years of college education. None of the children, with the exception of brothers and sisters and cousins, had been together before the beginning of the investigation period, or had had other school experience. They were unfamiliar with the entire second floor of the Nursery School building where the investigation room was located, except for those who had been brought to the doctor's office for physical examination. The experimenter came into contact with the child only in the observation situation. Added to these dissimilarities in conditions, the second group was less likely to be familiar

with much of the material used in the first part of the tests, than were those who had had considerable nursery school experience. It is for these reasons that the data for the two groups is, in some instances, analysed separately. In general, the observation period for each child in Group I covered from two to four weeks; in Group II the period ranged from four days to two weeks.

Reliability of the Original Experiment. Since two of the three series had been previously used, no effort was made to estimate the reliability or validity of these. In the case of the original experiment, however, various methods were employed to determine its reliability as a measure of attention. The visual part of the series was repeated twice with the children from Group I.

Comparison of the results by the Pearson product moment method yielded a correlation of .36 ±.13. This correlation is not only too low to indicate any significant reliability between the first and the second presentations of the visual stimulus, but, in addition, the probable error is so large as to make it impossible to place any confidence in the measurement.

The teachers' ratings were used as a further check on the reliability of the two series. A fairly high correlation, +.70 ±.08, was found between the teachers' ratings in Group I and the score for the auditory series. In Group II, however, the correlation approaches zero: +.07 ±.007. There may be many factors which account for this marked discrepancy, the most important of which is the difference in the experience of the raters. In Group I the ratings were made by experienced nursery school teachers who were familiar with the method and had had considerably more opportunity to observe the children whom they rated, both over a longer period of time and in a larger number of situations, than the teachers in Group II. Although the same ratings are correlated with the scores obtained from the visual stimulus, the same discrepancy does not appear. In Group I the correlation is +.30 ±.14 and in Group II +.29 to ±.14. Neither of the correlations obtained between the visual score and the teachers' ratings can be viewed with confidence because the probable error is too large in both cases. These scores give the first indication of a tendency which other aspects of the analysis emphasize in various ways, namely that the trait or process of attention is not identical in the two sets of situations. The common use of verbal directions in the nursery school may perhaps provide the teachers with a better opportunity to judge auditory than visual attention, and it may be that the ordinary judgment of attention is largely based upon this type of attention in place of any other.

When results from the entire group of subjects in the 2 series are correlated, a coefficient of only +.28 ±.10 is obtained. When the results from Group I only are used, the correlation is slightly higher, +.39 ±.13, and in this case, the probable error is relatively smaller and the coefficient may be regarded with more confidence as a measure of relationship. It is interesting to note that when a partial correlation is made between the scores of

Group I on the visual and auditory tests with the factor of the teachers' ratings held constant, the self correlation drops from +.39 ±.11 to +.19 ±.10, a significant drop of .2 points in correlation, but without a similar drop in the probable error.

These results, then, indicate two main trends, namely that auditory and visual attention are not identical but are probably distinct and specific traits or abilities; and secondly, that judgments of children's attention tend to be more accurate with respect to auditory than to visual attention, contrary to common supposition. Neither statement has received sufficient support in the data so far cited, but one is justified in concluding that such trends are at least indicated.

Differences between Visual and Auditory Attention. The difference, already referred to, between the scores obtained on the visual and on the auditory situations in the original experiment, have been studied from a variety of angles. In the first place, very low negative correlations are obtained when either set of scores is correlated with chronological age. The correlation between the auditory situation and age is −.13 ±.10 and the correlation between the visual situation and age is −.20 ±.11. The relationship between the scores on the visual and the auditory series has already been shown to be represented by the coefficient +.28 ±.10. If the formula for partial correlation is used and age is kept constant, the correlation between the two series is hardly altered at all, since there is only a drop from +.28 ±.10 to +.26 ±.11. In other words, the lack of correlation between the two tests is apparently not due to age differences.

The influence of the factor of training in terms of the length of time the individual child had been in the nursery school was studied. Group II was omitted in this correlation because the entire group had entered simultaneously, and from this point of view, presented a homogeneous group. The children in Group I represented a range of from two to twenty-two months in the Nursery School, with an average length of attendance of a little over 7 months. A somewhat significant difference in the correlations between the length of time in the nursery school and the two situations appears, for the correlation between the auditory situation and the length of time in the nursery school is +.11 ±.16 and the correlation between the visual situation and the length of time in the nursery school is −.14 ±.16. The size of the probable error in both cases makes it impossible to place a great deal of confidence in either correlation. However, it is interesting to see that a similar difference between the two aspects of attention persists. For Group I the correlation between these two aspects is +.39 ±.13. By means of partial correlation, when the length of time in the nursery school is kept constant, the correlation becomes +.41 ±.09. Because there is scarcely any change in the correlation between auditory and visual attention as measured in this experiment when the length of time in the nursery school is held constant, there is indication that whatever the difference between the two may be, it is not affected by those factors which are

altered through school experience and training.

Another measure of the factor of training can be obtained by means of the standard error of the difference between the scores made by Group I and Group II on the two series. For the auditory scores the obtained difference is 108 and the sigma difference is ± 32.9. There is practical certainty that the true difference will be greater than zero. As far as the visual series is concerned, the obtained difference is 66, the sigma of the difference is ± 48.8, and the chances are 99 out of a hundred that the true difference will be greater than zero. There is a difference, then, between the scores obtained for the two groups, but not one which accounts for an additional difference between auditory and visual attention.

Data with respect to the intelligence rating of individual children was only available for thirteen children in Group I. Owing to the fact that the tests were given over a considerable period of time, it was necessary to use intelligence quotient rather than mental age in comparison. The range represented quotients from 98 to 165 with an average of 118. Correlations between intelligence quotient and score on the two tests indicate differences similar to those shown by correlations involving length of time in the nursery school. The correlation between the auditory situation and intelligence is $+.34 \pm .16$ and the correlation between the visual situation and intelligence is $-.15 \pm .18$. Although both correlations are low and both probable errors are high, it is interesting to see that the negative coefficient appears once more in the case of the visual situation. When intelligence quotient is kept constant by means of partial correlation, the correlation between the auditory and visual situations is only raised from $+.32 \pm .17$ to $+.39 \pm .09$, indicating that differences in intelligence are not responsible for the differences between auditory and visual attention as measured by the experiment.

By means of the standard error of the difference the reliability of the obtained difference between the average scores for boys and girls on the 2 experiments can be determined. For the auditory series there is an obtained difference of 21 and a sigma of the difference of ± 32.9. The chances that the true difference between boys and girls will be greater than zero are a little more than half, or 69 out of a hundred. For the visual series the obtained difference is 24 and the sigma difference ± 49.8; the chances that the true difference will be greater than zero are the same as they are in the case of the auditory series. In other words the differences between the scores made by boys and girls are practically identical in both cases, and so the discrepancy between visual and auditory scores cannot be accounted for on the basis of sex differences.

Having eliminated chronological age, intelligence, school experience and sex differences as determining factors in the apparent differences in auditory and visual attention as measured by the present experiment, it remains to analyze individual differences. Methods for treating such data quantitatively are few. However, it is possible to correlate scores with certain types of overt behavior when they can be subdivided into two categories, by the use

of the method for discrimination of bi-serial correlation,

$$r = \frac{M_2 - M_1}{\sigma} \cdot \frac{r9}{z}.$$

The type of behavior which seemed to reappear with most regularity was an interest in, and questions about, the mechanical origin of the stimulus. Such questions took various forms:

R. D. (58).[2] "What is it? I don't know what it is."

G. P. (54). "What's it supposed to be? Why doesn't it stay on a long time? Is it warm? Is that fire there?"

D. R. (51). "How does it turn on? What is it made out of? Is there a light in there? Does it go on all night?"

R. K. (47). "What's that? What makes it go on? Oh, there's a lady downstairs who makes it go on."

M. R. (36.) "Where'd you get this thing? Can it burn you? Can I get close to it?"

G. P. (54). "What is it? Is it a victrola? Is it in here? Can I see it?"

All of those who either asked questions or offered explanations of the mechanical origin of the stimulus were placed in one category, and those who did not were placed in the other. On the face of it, this may not appear to be representative of a normal distribution. Although the behavior falls easily into two categories, it spreads out as a normal distribution from a merely passing interest in the mechanics of the stimulus to considerable curiosity. The correlation between the asking of such questions and the total score in the visual situation was found to be only $+.25 \pm .10$. In the auditory situation the correlation was $+.49 \pm .08$. The second of the two correlations may indicate a tendency for the auditory score to depend upon interest in the mechanics of the stimulus. This is not a basis for assuming that the difference between auditory and visual attention lies in the dependance of the former upon mechanical interest. It is rather an indication that the nature of the auditory stimulus used in this investigation, in order to attract and hold attention, presupposed an interest in what made it go.

What is of much more value than statistical treatment of individual differences is a qualitative analysis of the individual differences in behavior. Although in many cases the same type of behavior was displayed in both situations, the reactions of T. W. (40) provide an interesting contrast. In the visual situation in which his score is the largest, he walked confidently up to the light, stopped suddenly the first time it went on, and then nodded his head slowly up and down. At first he stood very straight with his hands on his hips, but soon he began to slump and his feet and hands became restless. He began to sigh and to breathe heavily and to stretch his back and shoulders. Finally after fourteen minutes he took something from his pocket and directed his attention to it and so he was told that he might go. In this case he quite evidently had imposed upon himself the strain of paying attention for an indefinite length of time, and was not capable of bringing the period to an end without outside intervention. On the second trial his general reaction pattern was similar except that after three and a half

[2] The numbers in parenthesis indicate the child's age in months.

minutes he said that he wanted to leave. During the auditory situation none of the strain or fatigue was present and he apparently had no hesitation about telling the experimenter that he was through and wanted to go. The antithesis of this behavior is to be found in the record of P. K. (29). She entered the room during the auditory experiment, asked a few questions, looked out the window, and then started to go out the door when she suddenly stopped and said: "Oh, hear. What's that?" then moved about the room some more, so noisily that the sound could not be heard, and then left the room. Her reaction was both late and very short-lived. A great many of the children apparently expected something to play with and would ask for it. F. V. (35) always asked for the material of the immediately preceding test, no matter in what series he was, at the moment, being observed. There was considerable divergence in the adaptive behavior exhibited during the auditory situation. The majority of the children were not aware that the sound came from the closet, at least at first, and generally looked behind the screen where the light had been, in an effort to locate it. M. R. (36) was the only one who thought that the noise came from outside the room, and actually went out into the hall to find it, asking questions all the time. T. R.'s (26) exploratory behavior with respect to the visual stimulus was unique. He blinked his eyes and turned his head back and forth apparently duplicating the intermittence of the sensation. He tapped on the floor and on the wall and table, looking quickly around to see the light after each tap, evidently seeking some connection between the flashing light and his own movements. B. A. M. (49) was the only child who noticed a thin crack between the screen and the wall through which it was possible to catch a glimpse of the light as it flashed on and off. She tried to run around the screen from the light to the crack before the light went off. This was, of course, impossible but she persisted in her attempt for some time. On the second trial with the visual stimulus she repeated this behavior, but paid no attention to the same screen during the auditory experiment.

The evidence presented by these examples of overt behavior, comments, and questions leads but to one conclusion, namely that individual differences are of more importance in an estimate of the qualities of attention, than any group variations due to age or sex or intelligence or training. How much these variations are due to individual habits of behavior and how much they depend upon the situation of the moment remains to be seen. Additional information with respect to individual differences may serve to indicate trends, even though they cannot present any positive proof.

Perseveration. The attempt has been made, in planning the two situations of the original experiment, to eliminate as far as possible the tendency to perseveration. The results from the original experiment have been compared with those from the study of perseveration made by Cushing. Correlations between the perseveration scores and age, in addition to bearing out Cushing's own findings, show a difference in favor of the younger children similar to that found in the origi-

nal experiment. When the auditory and visual scores are correlated with one another, the resulting correlation is +.72 ±.05. This is an extremely significant one, both because it is high and can be viewed with confidence, and because it is in marked contrast to a similar relationship for the original experiment, namely +.28 ±.10. In other words, the evidence points to the fact that though auditory and visual attention as measured by the experiment, are two distinct and dissimilar factors, auditory and visual perseveration are similar if not identical.

Further investigation of these relationships was made by correlating the visual situations in both experiments with each other, and the auditory situations with each other. The correlation between the visual situations is found to be +.40 ±.09 when all 36 cases are used and +.47 ±.07 when only group I is used. Both correlations are higher than the corresponding ones of +.33 ±.10 and +.30 ±.07 for the auditory situations. The relationships tend to remain much the same when the factor of age is held constant by means of a partial correlation. For the entire distribution, when age is partialled out, the correlation between the auditory situations becomes +.32 ±.10, and for the visual situations +.35 ±.10. When length of time in the Nursery School is kept constant for Group I the relationships are scarcely altered at all. For the auditory situations the correlation becomes +.28 ±.14 and for the visual, +.49 ±.12. In neither case is the change of any significance except in so far as the direction of the change may indicate that length of time in the nursery school is of more importance with respect to visual attention and perseveration than in the case of auditory.

The Original Experiment Compared with the Shacter Attention Test. The two situations from Shacter's attention test have been assumed to be typical of most of the tests of attention devised for use with young children. The scores present considerably less variation than is presented by either set of scores from the original experiment. The coefficient of variability of the Shacter attention test is 24.8 while for the original auditory series it is 84.9 and for the original visual series it is 134.7. However, the present investigation tends to indicate that individual differences are of considerably more importance than any group factors. If this assumption is true then a test which produces a rather homogeneous set of scores for attention is apparently not a fine enough measure.

The overt behavior and questions which were recorded for individual children during the test, were analyzed and show that there was no relationship between the total score and the relevancy of the comment made or the question asked. There was found to be slightly more of a relationship between the total score and the ability to discriminate form than between the total score and the ability to discriminate color.

The chief significance of these results lies in the fact that they add further evidence that scores on an attention test, in terms of time spent, are not descriptive of the attentive process at all, and that a study of the qualitative differences reveals much more with respect to the nature of that process as it actually is.

A Comparison of the Behavior of

Twins. The present investigation was fortunate in having among the subjects in Group I a pair of fraternal twins, 47 months old, whose behavior affords interesting contrasts in individual differences. There was considerable divergence in the opinions of the judges with respect to their attentive behavior but when the ratings were averaged M.'s (the girl's) score was 18.3 and B.'s was 17.3 while the average for the group was only 14.9. Time, both for the visual and for the auditory situations of the original experiment was closely related, but their behavior was entirely different. M. came behind the screen, turned around almost immediately and walked out, and then walked back in again, saying "Nice. See light?" She looked away frequently and then back at the light again each time, saying: "See, it goes. See, can't see. Pitty. Very nice." B. in the same situation, sat down on the floor near the light, then got up on his knees. He squirmed around a great deal and went in and out several times, looking constantly to the experimenter apparently for comment, and showing considerable interest in the writing of the record. On the second trial the behavior closely resembled the first in both cases, although the time spent was doubled in the case of B., and reduced to about a third in the case of M. In the auditory situation M. tiptoed about the room, and apparently located the sound as coming from the closet for she stood there a long time before going back to her chair to sit down. B. moved about a great deal, too, but with no apparent purpose, and no apparent interest in the sound. All three of these records serve to emphasize the fact that a time record of attention is not only an inadequate but frequently an inaccurate measure of the attention.

A wide difference in total time score is to be found in the case of the test for perseveration. As might be expected from the behavior described above, B.'s score is much larger than M.'s, five times greater to be exact. B. spent a very long time with the electric bell pushing it with his thumbs, his fingers, against the table top, and even on his knees and the toes of his shoes. M., on the other hand, merely rang the bell a few times and remarked that there was "noise in there (pointing to the closet). Pitty noise." They shifted their attention on the second trial with the auditory apparatus nearly the same number of times, M. a few less than the average for the group, and B. the same number of times more than the average. The fact that M. was especially apt at sound localization in both the original experiment and in the perseveration test may be due to superiority in sensory acuity over her twin. Such an advantage, in this case at least, is interesting in that it reduces the total time score on both tests, rather than increasing it as might be supposed. It would be extremely valuable if a high negative correlation could be found to exist between sensory acuity and perseveration. Since no information on that subject is available it is at least interesting to note an indication of it in the behavior of the twins. Though neither of the twins, when they entered the Nursery School, five months previously, was using normal speech, by the time the investigation was carried on, they had

both made considerable progress. M., however, was the only one who spoke at all in either of these experiments.

With the third series of tests, the Shacter attention test, the twins were outstanding in that, with one exception, they spent the longest time of any of the children, their scores being almost twice as long as the next longest score in the group. They were among the few children who used up all the materials before stopping; most of the children stopped long before the box was empty. Both used the same technique in color discrimination. They removed a large handful of pegs from the box and then picked out of it all of one or two colors, laying them aside and dropping the rest in the box. Though an obvious procedure it was followed only in three or four other cases. Their method of discriminating form was not so strikingly original since they merely fitted pegs in beads before dropping them through the hole, as did a large number of the other children. B. made a single comment during the series. When looking for a certain peg, he said, "I want a green one." M., however, talked quite a bit, always about the materials.

These contrasts have demonstrated the range of possible individual difference in the behavior patterns involved in attention. They present as striking similarities as they do differences, but their chief value in this connection is the emphasis they place upon the need for a qualitative estimate of the attention of young children.

SUMMARY AND CONCLUSIONS

The following indications have been brought out by an analysis of the data obtained in this investigation:

1. There is a significant lack of relationship between the scores obtained on the visual and on the auditory situations of the original experiment. This lack of relationship between the two factors persists even when age, sex, intelligence and school experience are held constant by statistical measures.

2. There is a difference in all scores between the two groups observed, in favor of Group I. However, within Group I there is no evidence that score is affected by the length of time in the nursery school. Therefore, the conclusion is drawn that there are other factors of more importance which distinguish the two groups from one another, namely, familiarity with the experimenter and with the experimental room, amount of previous experience with the materials, and the length of time intervals between the tests.

3. There is apparently little relationship between such qualitative aspects of behavior as relevant and irrelevant conversation, form and color discrimination, and the total time score.

4. In the case of perseveration, low correlations between total score and the number of shifts of attention indicate that there is no relationship between a tendency to perseveration and a tendency to shift the attention.

5. Analysis of overt behavior and comments indicates that significant variations in behavior do not appear in a score for attention based merely upon the amount of time spent.

6. Individual differences in the group studied appear to be of a great deal more importance than any developmental factors, in determining the nature and duration of the individual's behavior while attending. The selec-

tive character of the sampling, both from the standpoint of the age range and of the number of subjects, makes it impossible to conclude that the above statement holds true for the field of attention as a whole. It does indicate, however, that developmental factors may be of less importance than is commonly supposed, and that behavior patterns exist irrespective of age, sex, intelligence or training.

The most important single conclusion which is indicated is that auditory and visual attention are not identical or even similar processes, and that the individual's capacity to attend to one type of stimulus is apparently in no way related to his capacity for attention to the other. The practical considerations which are involved, could this conclusion be shown to be true, are of the greatest importance. Attention in education has largely been thought of as a unified process. If, however, it differs with the different senses all material for learning should not be presented in the same way and adjustments to individual facility might bring about a greater increase in the ability to learn. The assumption that individual differences far outweigh such factors as age, intelligence and training, would indicate a need for the revision of the norms and standards in learning which are based upon age or training factors.

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Development of Motor Control in Young Children; Coordinated Movements of the Fingers[1]

Margaret Karr

THIS study was undertaken to investigate the motor control and coördination of the hand and fingers of young children. A particular task which involves primarily the use of the fingers is set for the children; namely, the manipulation of scissors.

More specifically, this study concerns finger coördination with the purpose of finding:

(1) The relationship between the manipulation of scissors and chronological age
(2) The relationship between the ability to cut and mental age
(3) Additional information as a contribution to the question of handedness
(4) Sex, individual, and personality differences shown in the experiment.

Twenty-two nursery school children, 12 girls and 10 boys, ranging in age from twenty-four months to fifty-nine months, served as subjects. The mean chronological age was 42.5 months; the median chronological age was 43.2 months. Mental ages of the subjects, as tested by the California Pre-school Schedule I, ranged from 24 months to 71.5 months (with a mean age of 48.2 and a median age of 52.7 months).

A series of 22 papers, each containing one design was presented to the children in a definite order. The designs were drawn with black lines one-sixteenth of an inch wide on white medium weight mechanical drawing paper. Each line began on one edge of the paper, continued toward the center, and terminated with a small gold star. The series of designs ranged in complexity from a number of short vertical lines to a twisting line. One paper contained a 9-inch vertical line, another a 9-inch horizontal line, another a 12-inch diagonal line. Several papers had designs with vertical or horizontal combined with diagonal lines thus forming angles of varying degrees. Three more had each a curved line, a semicircle, and a complete circle. Five of these designs which began on the right side of the paper were mirror images, i.e., duplicate designs beginning on the left edge. The series was preceded by a plain practice sheet.

A simple frame was originated onto which each paper was thumb-tacked. The frame consisted of three strips of wood forming three sides of a 10-inch square, the fourth side being open in

[1] From the Department of Child Development, Mills College.

order that the subject might cut into the area. The frame was clamped parallel to the table top so that the cutting space extended between the table and the chair in which the subject was seated. The device held the paper steady, firm, and in a similar position for each person tested.

The scissors used in cutting were the steel-bladed and blunt-pointed kindergarten type, with evenly rounded metal loops for the fingers, and were easy to manipulate.

The children were tested on school days in the morning between nine and eleven o'clock. They were brought singly into the testing room. Before the cutting began, the subjects were given certain finger coördination items of the Merrill-Palmer Mental Test. Then the frame was clamped into place. The child's knees fitted under the extended part of the frame and his bent elbow was on a level with the table. Such a position was used consistently for each subject because it was the most comfortable arrangement obtainable and allowed freedom for arm and hand movements. The papers were presented in an arbitrarily set order. On the practice sheet, the subject was told to cut from the free edge into the paper anyway that he desired. As each paper of the series was presented, the child was instructed, "Cut *on* the black line, up *to* the star." The scissors were laid on the paper directly in front of the child, handles toward him so that he might pick them up with either or both hands.

The number of papers cut on one day varied with the age, attention and ability of the subject. On the average, four or five papers were presented at each testing period of twenty or thirty minutes. At such a rate, at least five days were needed to cut the series.

Several systems of scoring the cutting results were devised and checked one against the other. By examining the papers, false moves could be counted and recorded for each paper. *False moves* were defined as places where the scissors tore the paper rather than cut it; places where the child closed the scissors the full length of the blade and picked up the cut in the middle to go on; holes where the ends have hit the paper before the blade; sideway jags.

A second method of scoring graded the papers for accuracy. Each line was divided into three-inch segments. If the cut was on the line, four points were given for each division. If the cut deviated from the black line less than one-sixteenth of an inch it was graded three points. Two points were given for the segment if at any place the cut deviated from one-sixteenth of an inch to three-sixteenths of an inch. One point was allowed if the cut fell between three-sixteenths of an inch and one-half of an inch. No credit for cuts more than one-half of an inch away from the line, on either side. The perfect score for nine-inch lines was 12; twelve-inch lines, 16; fifteen-inch lines, 20.

A third method of scoring is a modification of the one just described. Four experienced nursery school teachers, A and B from one locality and C and D from another locality, cut the series of papers under the same specifications as the children. Then they rated the papers on a scale of difficulty in cutting from 1.0 to 5.9. The judges were

instructed to keep in mind the motor skills of young children. By the Spearman rank difference method, ratings of

A and B correlated...... .95±.01
C and D correlated...... .89±.03

The averaged ratings of A and B correlated with the averaged ratings of C and D .92 ±.02. Because of the high correlations obtained, the average of all ratings was used as a basis of difficulty, and the papers were weighted accordingly.

DATA

Results of the scissor-manipulation experiment have been studied with reference to chronological age and mental age. Only 15 children were able to cut the entire series. Their records have been analyzed with respect to handedness, false moves, and time required. Further differences in the ability of the children in the performance of this task were also considered.

The weighted and unweighted scores of the children were correlated with chronological age. Two children who cut with one scissor loop in each hand were eliminated from the relationship on the ground that their ability did not show finger coördination. The following correlations were obtained from the remaining twenty subjects. Spearman rank difference:

C. A. and unweighted score.............. r = .72±.08
C. A. and weighted score.............. r = .71±.08

The relationship between the age of the child and his ability to manipulate scissors is probably due, in part, to the increased physiological capacity of older children.

Comparison of the ability to cut accurately with mental age gave higher and more significant correlations:

M. A. and unweighted score.............. r = .85±.04
M. A. and weighted score.............. r = .84±.05

The greater correlation with mental age than with chronological age indicates that the ability to manipulate the scissors is a mental as well as a physiological accomplishment. For example, the scissors must be held perpendicular to the paper, closed to a certain degree, guided along the line. Some of the designs made it necessary to hold the hand in awkward positions while cutting. The child's insight into these problems is also involved in the correlation of score and mental age.

The weighted scoring system was of value in emphasizing the spread of the distribution of the results. A graph of these scores displays a bimodal curve; one group could cut very little, the other group cut well enough to attempt to follow the line. This bimodality of the curve may be due to incomplete sampling of the group studied; but a definite attempt was made to obtain subjects to fill the gap. These, however, were found to cut either acceptably or practically not at all. The question may be raised whether this is evidence of a maturational factor, whether the ability to oppose thumb and fingers in a scissor cutting motion appears when the hand has developed sufficiently.

Fifteen subjects cut the entire series. In most cases, they were able to manip-

ulate the scissors automatically and their attention could be focused on the line. They could hold the hand steady and direct the cutting, while the five children who made the lowest scores centered their attention on the scissors. The first group found difficulties in the mirror image lines. In these complicated situations, they, also, became absorbed in their finger coördination.

To determine whether speed and accuracy go together in this task, the following correlations were computed, using the Spearman rank difference method for the fifteen subjects who completed the cutting exercises:

Median time in seconds and unweighted score	$r = -.33 \pm .16$
Median time in seconds and weighted score	$r = -.31 \pm .16$

The correlations might have been higher if the time score had been more accurate. Since the children stopped frequently to talk during the cutting of a design, such individual differences made this measure only suggestive. The correlation between time scores and chronological age in this study was $r = .26 \pm .17$. The time required to cut did show personality differences for the individual children. Some took a long time consistently for each paper but longer for the more difficult ones; others cut the series rapidly; a few were inconsistent. The experimenter's subjective judgment, substantiated by her acquaintance with the children, is that the time scores were characteristic of the child's general reaction.

The number of false moves of the fifteen children who completed the cutting series were ranked from the highest to the lowest. Spearman rank difference method yielded the following correlations:

False moves and C. A.	$r = -.30 \pm .16$
False moves and M. A.	$r = -.59 \pm .12$
False moves and unweighted score	$r = -.76 \pm .08$
False moves and weighted score	$r = -.81 \pm .06$
False moves and median time	0 correlation

The correlation between false moves and chronological age was lower than the false moves and mental age. Such a relationship suggests that children with higher mental ages:

1. Close the scissors to make only the necessary length cut rather than closing them the full length of the blade
2. Fit the scissors into the cut and proceed evenly
3. Direct the scissors sideways rather than "jag" the scissors sideways to get back to the line.

Subjects who made higher scores also made fewer false moves. Children who cut slowly did not consistently make fewer or more errors than children who cut rapidly.

All but one of the 15 subjects changed from one hand to the other, or used the left hand on lines that were drawn from left to right. It is true that the cutting papers as designed encouraged this alternation. The assumption was made that the child who cut with the right, then left, and then both hands on a difficult paper showed less consistent use of the right hand than the child who alternated right and left. Therefore, the subjects

were ranked on a scale of diminishing use of one hand from right, right and left, right and left and both, to left. The rankings correlated as follows:

Consistent use of the right hand and C. A. .... $r = .77 \pm .08$
Consistent use of the right hand and M. A. .... $r = .55 \pm .13$

The findings support the theory that as a child grows older, he uses one hand more consistently. It is interesting to note that the correlation with mental age is the lower, although some of the mirror image papers would have been easier for the child to cut if he had changed to his left hand. The habit formed by learning and maturation probably is stronger in the child who is older chronologically.

Four items from the Merrill-Palmer tests which involve finger coördination were given all the subjects.

1. Folding paper
2. Closing fist and wiggling thumb
3. Cutting paper into strips
4. Opposing thumb and fingers

Eleven children passed the series. The median of their weighted score was 656. Three children passed 3 items. Their median weighted score was 518. Two children passed three items with their median weighted score 43. Of the four children who passed none of the tests, three received a score of zero, while one made an 8. The 2 children who were eliminated because they cut with both hands failed on the thumb and finger opposition test. Another child who failed this item made a cutting score of 550. The 2 children who made the lowest scores for the series failed on both of the finger coördination items.

The experimenter realized that some of the subjects have had more specific practice than others. A questionnaire was filled out by the writer during an interview with each child's mother. The purpose was to divide the children into the following classification:

Group A—cut very often at home
Group B—cut frequently at home
Group C—cut occasionally at home
Group D—never cut at home

From the groups who do cut at home, the girls use scissors more frequently than the boys. The median weighted scores show that the children who have had more home experience can cut more difficult papers better than those who have had less practice. One of the two children who cut with both hands fell in group C with a weighted score of 422. The other child fell in Group D with a weighted score of 14. The group who never cut at home was composed entirely of children under three years of age.

The children in the same six-month-age intervals were matched according to sex. Seven pairs were available. The median weighted score for the girls was 544 and for the boys 477, a difference of 67 points. This small advantage in favor of the girls is hardly significant. It may be accounted for by the difference in specific home practice or perhaps to an earlier maturation of girls.

The children were allowed to hold the scissors any way that they desired. Children with the higher chronological age were the children with the larger hands and they used one finger and

thumb to manipulate the scissors. The median chronological age of this group was 54 months. The children with the smaller hands, median chronological age 43.5 months, fit two fingers into one loop. The youngest children had not learned the most efficient way of holding the scissors, or perhaps their hand muscles are not developed sufficiently to manipulate the scissors in an adult fashion.

Individual differences in the children's method of cutting appear in the experimenter's comments. Some have used extreme care, watching the line attentively. They were apt to cut more slowly and to make precise small snips. Others slashed one cut after another across the paper, closed the blade the full length at one stroke. They made fewer false moves, but a poorer accuracy score than the first group. Many of the children steadied the scissors by holding the upper blade with their free hand; usually the left hand did the guiding when the right hand was in an awkward or difficult position. There was a marked difference in the angle at which the scissors were held. The "best" cutters held the scissors so that the intersection was on the line, one blade above and one blade below, and the scissors perpendicular to the paper. Some children cut with their hand above the paper, blades pointed down. Others cut with their hand below the paper, blades pointed up. A more popular position, which increased the steadiness and accuracy, was to slide the upper blade along the line and close the lower blade up to meet it. Seven of the children, all boys, closed the scissors so forcefully that the paper tore, sometimes along the desired place. One child when cutting a difficult line, held his right hand in the air, opening and closing the fingers as he opened and closed the scissors with his left hand. The child displaying this bilateral drainage, was aged 44 months, group C in home practice, and ranked eleventh in accuracy of cutting by the weighted score.

Two of the children could open but could not close the scissors; several held the scissors parallel with the paper so that they made no cut. From this group, one boy aged thirty-one months, was given 6 practice periods, and one girl aged twenty-four months, was given 6 practice periods during the two months. They were instructed how to hold the scissors also how to open and close and fit them into a paper. At the end of the training, the children could make successive cuts holding the paper with the free hand.

The children's remarks show certain personality traits. Some gave up easily, saying "I can't," with each paper presented. Others made positive remarks such as, "I think I can cut this." "I'll try." Many of the children imagined the design to look like an object. Several of the older children recognized resemblances to letters. Some of the children repeated syllables or phrases over and over as they cut. Several criticized their own efforts. Two of the children talked incessantly about other matters. Many made remarks which were suggested by the papers or the immediate surroundings. All but the smallest children made comments about the lines, the stars, observing differences and similarities between the papers.

RESULTS

Results of this study are merely suggestive for they are based on a small number of cases. They relate to finger coördination in a specific task in which the child cuts along a line on paper held horizontally and firmly for him. An analysis of the data obtained leads to the following tentative conclusions:

1. The chronological age of the subjects determined to some degree the ability of the children to cut on the line.

2. The more intelligent children cut more accurately than the less intelligent ones of the same chronological age.

3. The graphic distribution of the subjects' cutting scores showed a bimodal curve, one group being capable of cutting sufficiently well to make an acceptable record on the test, and one group being unable to manipulate the scissors adequately.

4. There is no significant relationship between the median time required to cut the series and the accuracy of the cutting.

5. Speed in cutting did not increase with chronological age.

6. The children with higher mental ages and the children who followed the line more accurately, also made fewer false moves.

7. Consistency in the use of the right hand became greater as the child grew older in years. The correlation was not as great when consistency of the hand used was compared with mental age.

8. Subjects who passed four finger coördination items from the Merrill-Palmer mental test, made higher scores on the cutting papers than the children who failed one or more items.

9. The group of children who had had more home practice made a higher median cutting score than the children with less specific practice in using scissors.

10. Sex differences were slightly in favor of the girls.

11. Individual differences in methods of holding the scissors appeared to be dependent on the size and muscular development of the hand.

12. Methods of cutting showed individual and personality differences for each subject.

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